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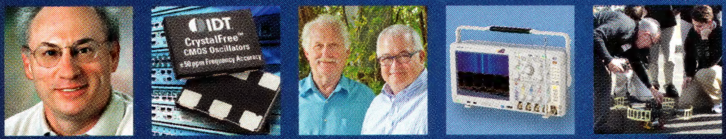

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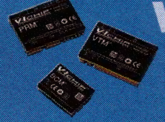

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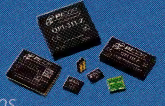

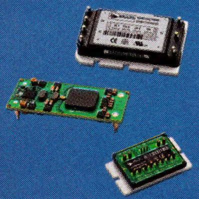

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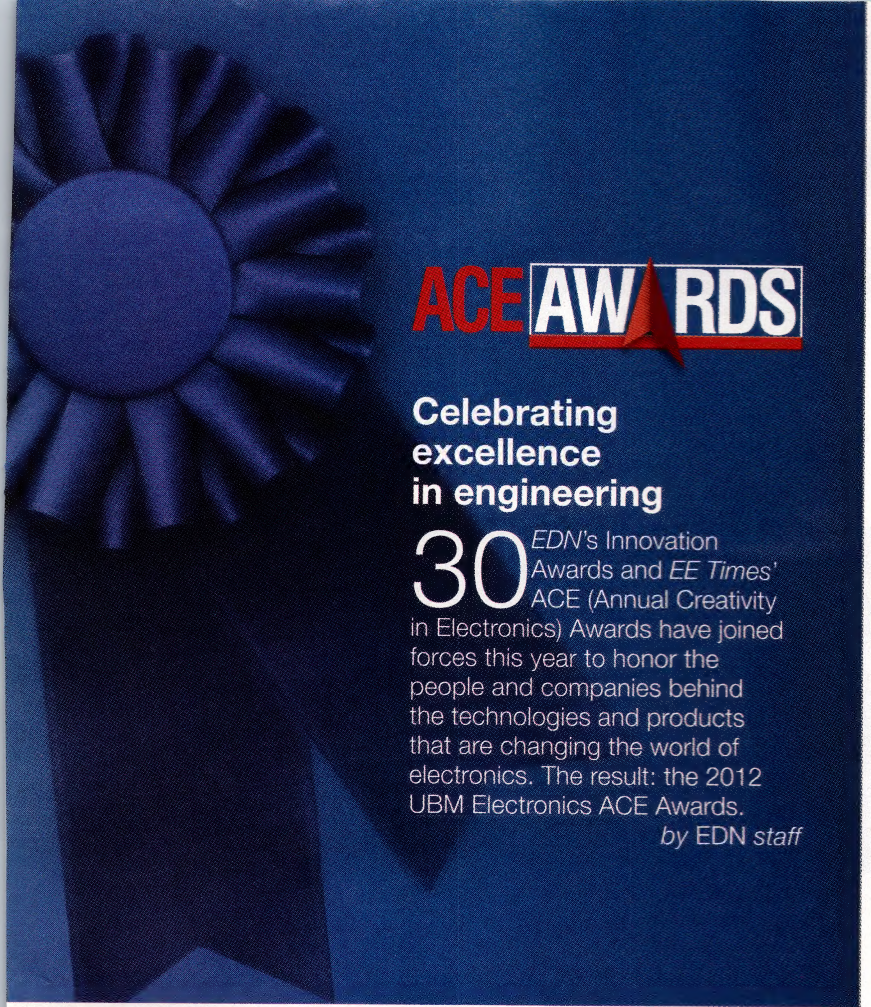
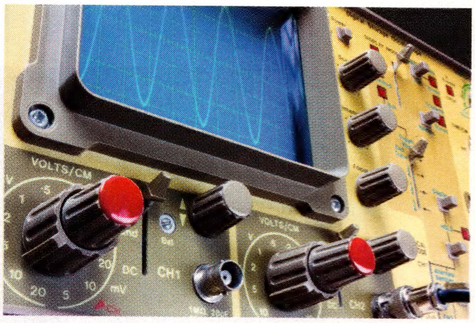


Celebrating excellence in engineering

30 *EDN*'s Innovation Awards and *EE Times*' ACE (Annual Creativity in Electronics) Awards have joined forces this year to honor the people and companies behind the technologies and products that are changing the world of electronics. The result: the 2012 UBM Electronics ACE Awards.

by EDN staff



Oscilloscope math functions aid circuit analysis

25 Use an oscilloscope's math to measure parameters that you can't measure directly.

by Dwight Larson, Maxim Integrated Products

Compliance with POE safety standards is critical when moving beyond 60W

41 Understand the realities of safely and effectively delivering high power levels that comply with the latest POE standard.

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Understand and reduce dc/dc-switching-converter ground noise

45 Once you understand the two primary noise sources, you can minimize them.

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COVER IMAGE: THINKSTOCK

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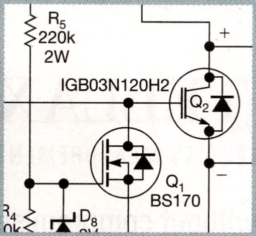

49 Simple circuit lets you characterize JFETs
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52 Use a three-phase rectifier and voltage reducer for offline single-phase power supplies
54 Lamps monitor beat frequency

▶ Find out how to submit your own Design Idea: http://bit.ly/DesignIdeasGuide.

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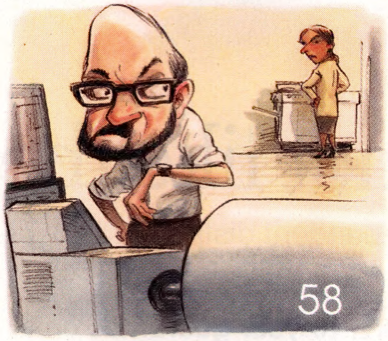

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Benchmark MOSFETs

DC-DC Buck Converter and POL Applications

SO-8

Part	V	nC	mΩ
IRF8788PBF	30	44	2.8
IRF8714PBF (Ctrl)	30	8.1	8.7
IRF7862PBF (Sync)	30	30	3.7

PQFN (5x6)

Part	V	nC	mΩ
IRFH5303	30	15	4.2
IRFH5304	30	16	4.5
IRFH5306	30	7.8	8.1
IRFH5301	30	37	1.9
IRFH5302	30	4.8	2.1
IRFH5302D	30	26	2.5

PQFN (3x3)

Part	V	nC	mΩ
IRFHM831	30	7.3	7.8
IRFHM830	30	15	3.8
IRFHM830D	30	13	4.3

PQFN (2x2)

Part	V	nC	mΩ
IRFHS8342	30	4.2	16
IRFHS8242	25	4.3	13

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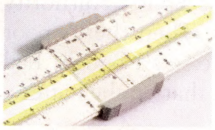
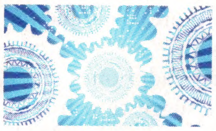


In response to "Overengineering: How much is too much?" a 1998 editorial by former *EDN* Technical Editor Paul Rako, http://bit.ly/zvqi6l, Jeff Luminais comments:

"I have always felt that one hurdle that has to be overcome for any engineer is to resist the little voice inside that says, 'You are not good enough.' (This effect is even more pronounced in many young software engineers.) This [belief] often leads to compensatory behavior; that is, proving to yourself that you are good enough by overcomplicating the design. The best designs use just enough technology to accomplish the goal in a cost-effective manner."



In response to "Do, make, design, build, and fix the future of STEM," an editorial by *EDN* Managing Editor, Online, Suzanne Deffree, http://bit.ly/zVxH5r, TJM comments:

"I've been involved in Vex and FIRST robotics. It is truly inspiring, and ... it brings me [hope] to see these kids in action.

One criticism I've heard of our university system is that the fun in learning that these kids have experienced in elementary/middle school/high school isn't happening in college. Maybe beer and hormones [are] getting in the way ;(

It seems to me that the focus has been on STEM, but I think we would be better off with STEAM (science/technology/engineering/art/math). It seems that the maker community understands that [concept]. Leonardo da Vinci comes to mind. We as a culture need to promote development of both sides of the brain."

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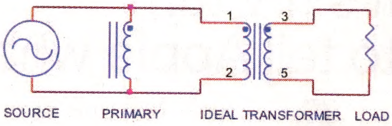
CONTENT

Can't-miss content on EDN.com



USING A POWER TRANSFORMER AT A FREQUENCY IT WASN'T DESIGNED FOR

A perennial question for designers is whether a power transformer built for one line frequency can be used with another.

http://bit.ly/GNrUCf

IN-BROWSER CIRCUIT SIMULATOR TACKLES CIRCUITS FROM SIMPLE TO COMPLEX

Analog- and mixed-signal simulations should be part of every circuit designer's tool kit—if only to enable them to say what they dislike or distrust about them. CircuitLab is a brand-new start-up from two MIT EE grads that makes circuit simulation about as painless as possible: It's all within the browser.

http://bit.ly/ygv3Xm

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Opportunities to get involved and show your smarts

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There will be more than politicians in Washington this April. Come on down and hang out with scientists and engineers at the second USA Science & Engineering Festival. This event will feature more than 3000 fun, interactive exhibits; more than 100 stage shows; and 33 author presentations, making it one of the largest celebrations of science and engineering in the United States. Join editors from *EDN*, Innovation Generation, and *EE Times* at the Walter E Washington Convention Center in Washington on April 28 and 29. Find more information at www.usasciencefestival.org.

BY PATRICK MANNION, DIRECTOR OF CONTENT

It's my turn to tell Apple what to do

Apple: Make me a pair of decent headphones. That's it. Then, take the remaining $87 billion left over after your stock buyback and figure out how to stop people who don't know what they're talking about from telling you what to do.

It's pretty amusing when you think about it. Apple is right now the most exciting and successful technology company in the world. Yet, bystanders with no skin in the game are happy to sit back and tell it what to do and act as if it matters what they say.

For example, many may exclaim that it's just not "right" that Apple employs so many workers overseas. I'm not as smart as the officials at Apple or many of these people who criticize it, so I must defer to the outcome to come to a conclusion: Apple ended 2011 sitting on more than $97 billion and can now give its shareholders dividends, which the company hasn't done since 1995. Oh, and I also have a cool iPhone and am looking forward to getting an iPad 3, because it's great technology at a relatively reasonable cost. Thank you, Apple, for changing the world and making those who were asleep at the wheel pay a bit more attention to innovation rather than stagnation.

Besides my headphone problem, which I'll elaborate upon later, what got me on the give-advice-to-Apple train? It was a pleasant and refreshing video from physicist Brian Cox on BBC (**Reference 1**). In it, Cox doesn't tell Apple what it should or shouldn't do; he just puts its potential in perspective, relative to the United Kingdom's and most other governments' entire government R&D budget over the past 20 years. He then imagines what could happen if these governments were to put aside some of that capital to free up a few engineers to have fun, to follow their curiosity, "to literally play at the edge of our knowledge," instead of doing targeted research focusing on the bottom line. Cox was talking about the kind of research that was once the hallmark of Bell Labs scientists of yesteryear. What could crystallize from that curiosity-led research? I particularly like his comment that the "electric light wasn't invented by continuous R&D on the candle."

So, what can Apple do? For one thing, how about more research into headphones? I have bought—and for various reasons have dumped—at least four sets over the past year. I like audiobooks, I travel a lot, and I like to jog when and where I can and to listen to music and then make and take calls when necessary. I know I could spend hundreds on a pair of headphones, but then I'd have to worry about losing that investment. Yet, what I find for less than $100 isn't working out too well, either. Big headphones are too bulky; ear-bud headphones block out too much ambient sound, which is a bad scenario for running, and they pop out when you perspire. "Athletic" headphones from companies such as Sports Authority lack microphones. Then there's poor design: Two of the sets I bought had bum microphones that crashed after a couple of months.

On my last trip, I bought a pair of comfortable headphones at Brookstone. They are so comfortable that I forget I have them on; they allow me to hear ambient sounds yet have decent sound reproduction. I'm now listening to Walter Isaacson's biography of Steve Jobs (**Reference 2**) and wondering why Jobs didn't spend more time making better headphones.

Beyond better headphones—and that idea is just a suggestion from a user, not advice—I wonder what Apple could do with all those billions. Could it do more research into understanding the brain and how to interface it with technology? Could it play more at the nexus of physics, chemistry, and biology to create new areas of exploration and innovation? Neither the iPad 4 nor the iPhone 5 excites me, though they may make investors happy—not that there's anything wrong with that. I'm sure that somewhere in my 401(k) plan there are a few bucks invested in Apple. So, Apple, go forth and prosper!

In the meantime, where would *you* spend $87 billion if you could play at the edge of our known universe? Also, if you have a suggestion for a pair of less-than-$100 headphones with a microphone, let me know! **EDN**

REFERENCES

1. Cox, Brian, "Apple could reignite 'Victorian age of engineering,'" British Broadcasting Co, March 2012, http://bbc.in/GACsp3.
2. Isaacson, Walter, *Steve Jobs*, Simon & Schuster, 2011, ISBN: 978-4516-4853-9.

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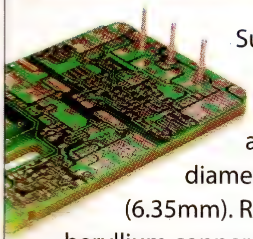

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INNOVATIONS & INNOVATORS

Adlink expands PXI/PXIe-instrument family

PXI and PXI Express continue to grow as platforms for automated test. Targeting that market, Adlink has added a chassis, a controller, and two I/O modules to its PXI product line. The $3600 PXES-2590 chassis provides nine hybrid PXI/PXIe slots—an industry first, according to the vendor. The chassis provides as much as 8-Gbyte/sec data throughput, with 1 Gbyte/sec dedicated to each I/O slot. The chassis uses four-lane PXIe, in which each lane handles data transfers for two I/O slots. Adlink has also released the PXIe-3975 system-controller module, which uses a 2.4-GHz quad-core processor.

The $3600, two-channel, 24-bit PXI-9527 dynamic-signal-acquisition digitizer module has two analog outputs and is also available in a PCI version, the PCI-9527, for applications in a desktop or an industrial computer. The module's maximum sample rate is 432k samples/sec on each channel simultaneously sampled because it uses a dedicated ADC per channel. Targeting use in audio and vibration applications, the PXI-9527 contains signal conditioning for integrated electronic-piezoelectric sensors.

The company also offers the $2700 PXIe-9842 module, which samples at speeds as high as 200M samples/sec with 14-bit resolution and 100-MHz analog bandwidth on one channel. It's also available as the PCIe-9842 for desktop computers. All modules have software drivers for Windows 2000, XP, and Vista/7; LabView; and Matlab.

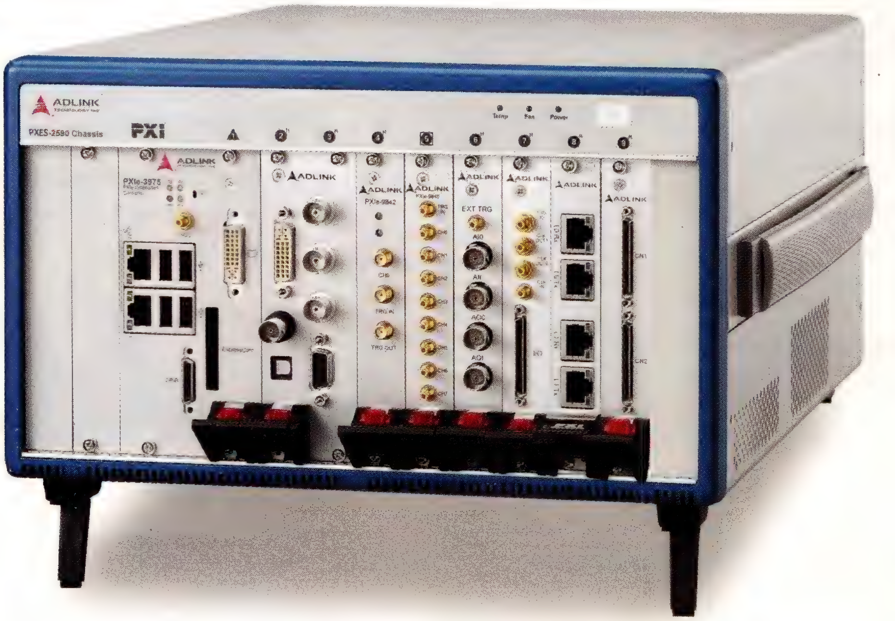
—by Martin Rowe

▷**Adlink Technology**, www.adlinktech.com.

TALKBACK

"Pushing for more engineers devalues the work of [currently practicing] engineers: excess-supply economics. Many engineers live in cubicles, making little more than a draftsman, and lawyers have nice offices, making two or three times more than any engineer."

—Engineer Ron Carlson, in *EDN*'s Talkback section, at http://bit.ly/yizq5V. Add your comments.



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The smart grid isn't getting smart enough fast enough, says MIT report

As the US power grid attempts to accommodate less predictable solar- and wind-based energy sources, the grid's speed becomes key to balancing fuel-burning power sources with renewable sources. Unfortunately, the power grid is not getting smarter fast enough, according to a recent report on NPR from the Massachusetts Institute of Technology's Energy Institute (**Reference 1**).

The idea of a smart grid brings to mind the fancy new meters that the utilities have been installing in homes that allow consumers to have greater insight into how much energy they are consuming and when and at what cost they are consuming it. However, at the level of intelligence companies such as Cisco and Silver Springs are pushing, "smart grid" means really smart, such as making energy-routing decisions at nearly instantaneous speeds.

Human operators currently make these decisions and base them on a combination of weather forecasts and the energy available from reliable fuel-burning plants. In California, for example, these baseline energy sources are shifting to the use of natural gas, a source that can come online and go offline more quickly and more economically than coal or nuclear power and also is cleaner than using coal. "The operator does not have control of when to turn [the renewable-energy sources] on and off," says Ernest Moniz, director of the Energy Institute at MIT. "It's a new challenge that we just have to meet, and we're not doing it at anything [approaching] the pace that … we need."

> Grid operators could accommodate the vagaries of wind and solar if they moved power around the grid minute by minute instead of hour by hour.

Another equally volatile component is that the grid is prone to failures that human operators cannot resolve quickly enough. Jeffrey Taft, an intelligent-grid architect for IBM and now in a similar position with Cisco, talked more than four years ago about how an intelligent grid is more robust (**Reference 2**). "There are a lot of parameters that you have to derive from basic waveform data," he said. "The power-distribution system is a three-phase system with complex connections. Its waveforms should nominally be simple sine waves, but … in practice, they're not, and you have to do sophisticated signal processing just to extract the parameters that tell you what's going on. Through digital signal processing, we get the information that tells us the real and reactive power flow that detects and locates problems in fault signatures and event correlations. We can tie that data together across multiple sensors and multiple power lines.

"For example, an ordinary circuit breaker can operate multiple times to see if a fault is going to 'self-heal.' Let's say a branch falls and shorts out two power lines. The short may be temporary and burn away; you don't want to trip a circuit breaker and lose power due to a temporary glitch. So, the circuit breaker opens up the circuit, waits, closes it, and sees if power is there. It can repeat this process several times, and, every time the breaker closes, it causes another surge of current through the breaker, the transformer, and the lines, causing serious stress on the equipment. If you could tell immediately from the power waveforms that it was going to be a permanent fault, you wouldn't do the reclose cycling. Other power scenarios may play out over weeks or months."

Michael Goggin, manager of transmission policy at the American Wind Energy Association, the biggest industry group for wind energy, thinks that solving the problem of balancing and routing energy sources is easier than MIT makes it out to be. "There are lots of misconceptions about backup power," he says. "All power plants are backed up by all other power plants." Goggin adds that grid operators could accommodate the vagaries of wind and solar if they moved power around the grid minute by minute instead of hour by hour as they do now, a scenario that requires the level of intelligence that Cisco and Silver Springs champion.

According to the report, "One thing the experts agree on: Since wind and solar energy are all about the weather, grid operators will need to hire a lot more weather forecasters." A better forecast would be for the need for utilities and their contractors to hire DSP and communication engineers.

—by Margery Conner

Massachusetts Institute of Technology, www.mit.edu.

National Public Radio, www.npr.org.

DILBERT By Scott Adams

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REFERENCES

[1] Joyce, Christopher, "Power Grid Must Adapt To Handle Renewable Energy," NPR, March 12, 2012, http://n.pr/zk9DL4.

[2] Conner, Margery, "IBM's Jeffrey Taft: bringing intelligence to the power grid," *EDN*, Sept 3, 2007, pg 26, http://bit.ly/zDj1hR.

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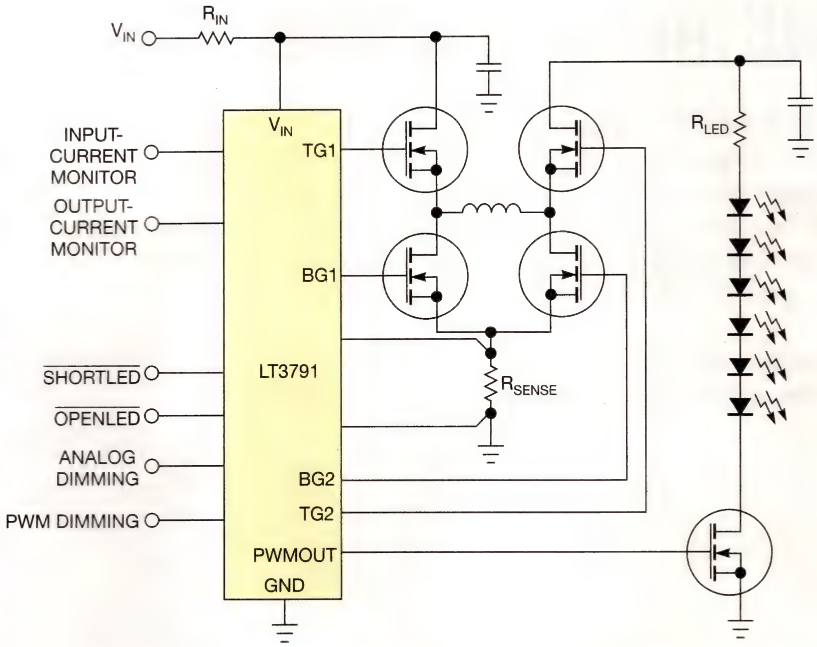
Buck-boost controller for HB LEDs delivers more than 100W

High-brightness LEDs offer many advantages, making them suitable for diverse applications, but that diversity brings with it the problem of how to provide the requisite power with proper regulation and protection, especially when the source rail has dramatic transients, such as those in automotive-load dumps, for example. Addressing this problem, the LT3791 synchronous buck-boost converter driver/controller for HB-LED strings supplies 5 to 100W over a 4.7 to 60V input range with high efficiency; tight output regulation; and high output-current accuracy, which is critical in many situations. It also operates from voltages lower than, at, or higher than the desired output voltage.

The device includes a four-switch buck-boost controller, which works with four external switching MOSFETs to deliver current and, therefore, power to the LEDs at efficiency as high as 98.5%. Current output is accurate to ±6%, and output voltage accuracy is ±2%, so the unit can operate as a constant-voltage source. Switching frequency is user-settable at 200 to 700 kHz, and the device requires only one inductor.

Three internal control loops monitor input current, LED current, and output voltage for performance and reliability. For the increasing number of applications that require dimming, the IC can use either analog or pulse-width-modulated dimming control. For the inevitable fault scenario, the IC features protection against both open and shorted LEDs and reports these malfunctions using status lines. Further, the output voltage disconnects from the input voltage during shutdown. The LT3791 comes in a 38-lead, thermally enhanced TSSOP; operates at –40 to +125°C; and sells for $4.75 (1000). Versions are also available for –40 to +150°C and –55 to +150°C. **—by Bill Schweber**

▷**Linear Technology Corp**, www.linear.com/product/LT3791.



The synchronous LT3791 buck-boost driver/controller supplies HB-LED strings; operates lower than, at, or higher than the output rail; and tolerates erratic supply rails.

IMEC offers 14-nm development kit

European research institute IMEC has released an early-version process-development kit for logic to address the 14-nm node. The kit supports technologies including FinFET devices and extreme ultraviolet lithography. It contains device-compact models, parasitic extraction, design rules, parameterized cells, and basic logic cells.

The 14-nm kit is part of IMEC's Insite collaborative-research program, in which Altera Corp, Nvidia Corp, and Qualcomm Inc are reportedly participants. IMEC is making the kit available to its research partners and will follow it with incremental updates. IMEC and its partners are developing a 14-nm test chip using this kit, which they plan to release in the second half of this year. IMEC operates a 300-mm-node research wafer fab that contains an EUV-lithography stepper.

One of the main purposes of the kit is to help companies to develop processes with FinFETs. These fin-shaped transistors that sit on the wafer surface have a larger drive per unit footprint and higher performance at low supply voltages than do traditional planar technologies. Evolutions of the kit should introduce the use of high-mobility channel materials. Such materials include germanium, compound semiconductor materials, and graphene. The kit supports both immersion and EUV lithography, opening the way for a gradual transition from 193-nm immersion to EUV lithography. The production of a test chip will allow the physical measurement of performance and power consumption and the first testing of the device, interconnect, process, and lithography assumptions. —by Peter Clarke

▸IMEC, www.imec.be.

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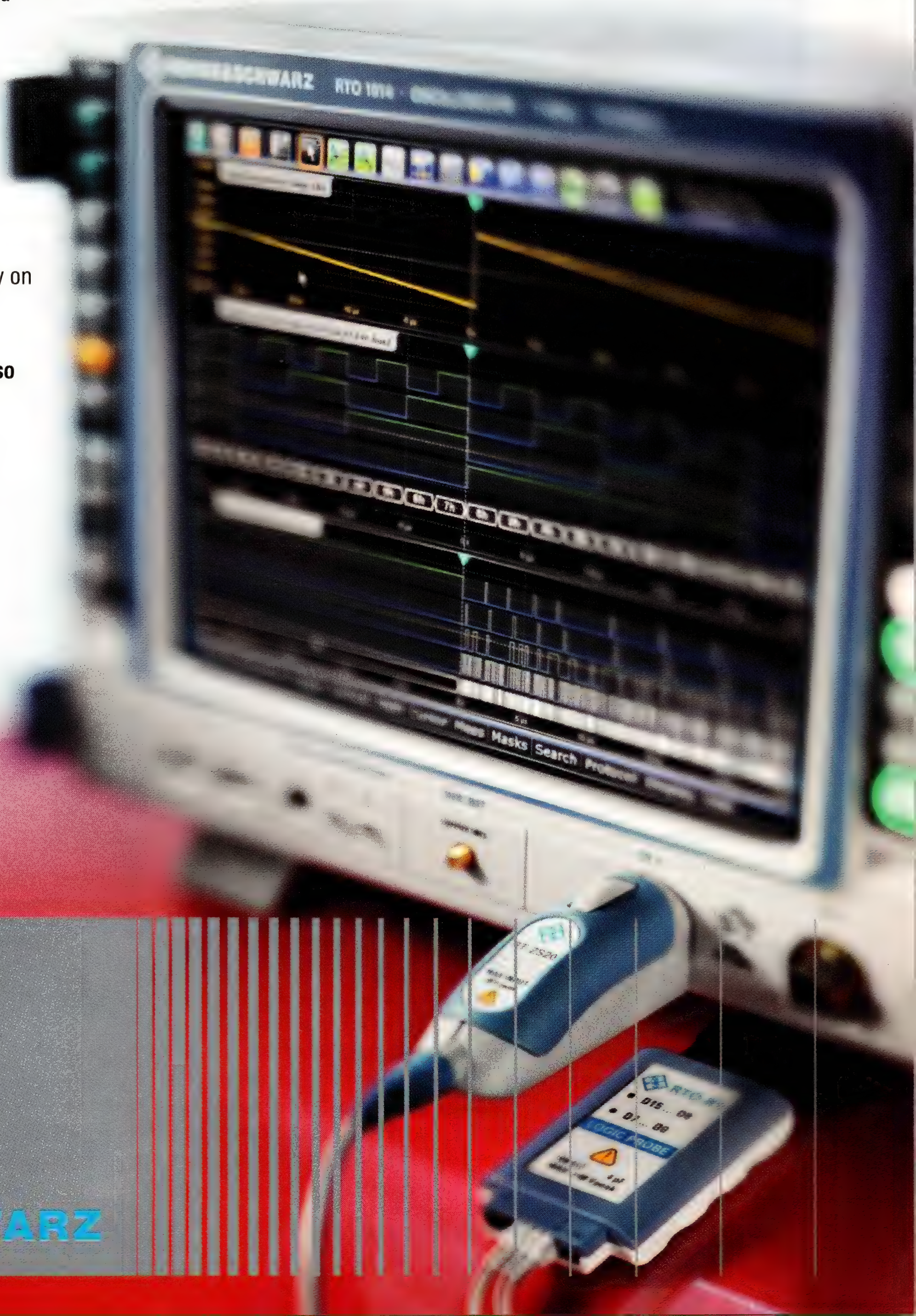
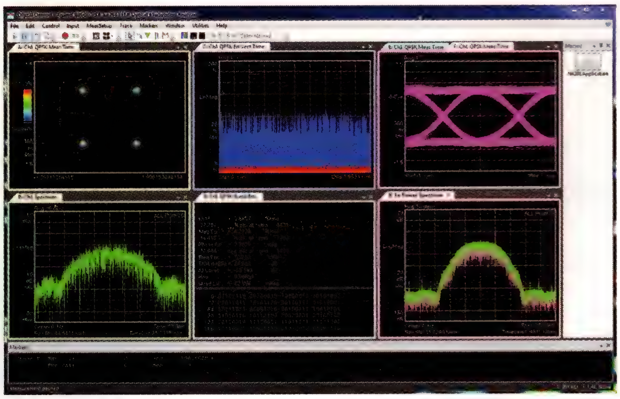


ROHDE&SCHWARZ

Analyzer lets you examine optical and electrical data streams

Complex modulation, such as quadrature amplitude modulation and quadrature-phase-shift keying, can achieve data rates of more than 25 Gbps per lane. These techniques have become more widespread over the last few years as 40- and 100-Gbps links become more popular. In some labs, engineers are developing enough optical and electrical products to warrant the need for more than one optical-modulation analyzer. Seeing that trend, Agilent Technologies has developed the four-channel N4392A optical-modulation analyzer, which has a 15-in. screen. Borrowing from popular oscilloscope packaging, the N4392A relies on height rather than depth, taking up relatively little bench space. With a weight of 13 kg (28.7 lbs), the N4392A is light enough to travel from bench to bench.



The N4392A optical-modulation analyzer relies on height rather than depth, taking up relatively little bench space. It is light enough to travel from bench to bench.

Modulation analysis on both optical and electrical signals is also moving from the lab and into production, where components need verification. The N4392A can let you view constellation diagrams and perform vector-signal analysis on an optical transmitter's output modulation. Eye diagrams let you see demodulated data streams. Because engineers can use the instrument for electrical or optical signals, it's available in three versions. The N4392A is available with optical receivers, electrical receivers, or both. Each receiver contains a 63G-sample/sec ADC and an RF amplifier, which enables the instrument to capture 32-Gbaud modulated signals. The four electrical signals are differential; hence, it has eight connectors on the front panel. The optical receiver covers the range of 1527.6 to 1565.5 nm. Prices start at $165,000.

—by Martin Rowe

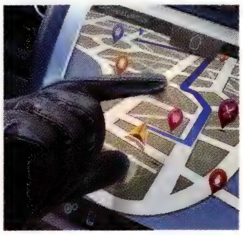
▷**Agilent Technologies**, www.agilent.com.

Single-layer touchscreens gain new controllers, ITO sensor

Smartphones and tablets, with their infinitely customizable multitouch screens, have trained consumers to expect the same degree of versatility in all devices, from cars to refrigerators to medical electronics. Targeting these users, Atmel's MaxTouch line of touchscreen controllers supports consumer and industrial applications. The company has now added the mXT768E and mXT540E automotive-qualified controllers for 5- to 10-in. touchscreens and touchpads in center-stack displays, navigation systems, radio-human-machine interfaces, and back-seat entertainment systems.

Conventional controllers for capacitive touchscreens require a shield layer within the multilayer touchscreen to prevent noise coupling from the LCD. These automotive-qualified MaxTouch devices offer a signal-to-noise ratio of 80-to-1, eliminating the need for shields; enabling a single-layer sensor designs for lower-cost, thinner stacks; and resulting in higher product yield during automotive-system production. A high SNR also enables detection of touches from a gloved finger, an important operating mode for automobiles. The devices embed single- and dual-touch-gesture calculation as well as postprocessing algorithms, which eliminate the detection of unintended touches. Users can perform multitouch gestures, such as pinch and stretch, but the system classifies and rejects unintended touches, such as a resting hand on the screen.

The Atmel controllers work with the larger touchscreens of 5 to 10 in. that the automotive world requires. Smartphone touchscreens, however, are 5 in. and smaller, and thinness and lightness are paramount in these handheld devices. Targeting the single-layer-touchscreen market for handheld mobile applications, Cypress Semiconductor's new SLIM (single-layer-independent-multitouch) sensor provides touchscreen accuracy and responsiveness with a true single-layer sensor panel. It enables users to perform gestures such as pinch, zoom, flick, drag, swipe, and others requiring more than two fingers. The single-substrate, single-layer indium-tin-oxide touchscreen sensor requires no additional insulation layers or bridges, reducing the sensor module's thickness and the sensor's cost by approximately 40%. Manufacturers can deposit SLIM directly on the device's cover glass.



Atmel's mXT768E and mXT540E automotive controllers find use in 5- to 10-in. touchscreens and touchpads in center-stack displays, navigation systems, radio-human-machine interfaces, and back-seat entertainment systems.

Cypress' new TMA140 TrueTouch touchscreen controllers for low-cost mobile phones offer multifinger support and high SNR for screens as large as 5 in. They also support the company's Charger Armor, which uses adaptive frequency hopping and other techniques to prevent false touches due to excessive noise from a charger.

—by Margery Conner

▷**Atmel**, www.atmel.com.

▷**Cypress Semiconductor**, www.cypress.com.

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ROHDE&SCHWARZ

Overvoltage protectors use reverse-bias blocking

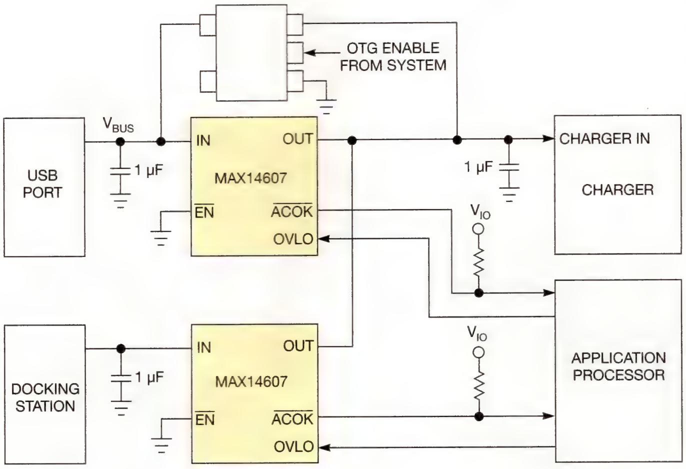
Maxim Integrated Products' new MAX14606 and MAX14607 overvoltage protectors feature reverse-bias blocking so that two power sources can be safely interfaced simultaneously without damage to either one. Two integrated back-to-back FETs prevent the voltage at the intended output from feeding back into the input. Without this reverse-bias blocking, users would have to use multiple discrete, space-consuming external components to protect the end equipment.

Targeting use in portable electronics, the MAX14606 and MAX14607 automatically choose the accurate internal trip thresholds. The internal overvoltage-lockout voltages are typically 5.87V±3% and 6.8V±3% for the 14606 and 14607, respectively. The units also have thermal shutdown to protect against overcurrent events. Other features include soft start to minimize inrush current and internal 15-msec start-up debounce.

The devices offer operating-input-voltage protection of 2.3 to 36V and an ac-OK bar, which indicates that the input is in range. The MAX14606 and MAX14607 operate over the extended temperature range of –40 to +85°C; come in nine-bump, 1.3×1.3-mm WLPs; and sell for 91 cents (1000).

—by Fran Granville

▷**Maxim Integrated Products**, www.maxim-ic.com.



The MAX14606 and MAX14607 overvoltage-protection devices feature internal, back-to-back, 54-mΩ-typical-on-resistance FETs that allow as much as 3A of continuous current and protect low-voltage systems against faults as large as 36V.

TI partners with iRobot to take OMAP into robotics

Texas Instruments has partnered with iRobot Corp, developer of the Roomba vacuum cleaner, to develop robotics technology employing TI's open multimedia applications platform. TI developed the OMAP range of multicore devices as application processors for mobile phones, and they generally use an ARM-processor core plus one or more specialized processors to support multimedia and wireless communications.

The latest generation of OMAP, the fifth, uses a dual-core Cortex-A15 processor, which TI licensed from ARM, and the PowerVR SGX544 dual-core graphics, which TI licensed from Imagination Technologies Group. TI has so far designed two ICs. The OMAP5430 targets products with tight size constraints and supports dual-channel, LPDDR2 package-on-package memory. The OMAP5432 targets use in mobile computing and consumer products that are more cost-sensitive without the size constraint and that support dual-channel DDR3/DDR3L memory. Both devices use a TI-defined, low-power, 28-nm fabrication process. TI does not indicate whether partnership with iRobot would use OMAP 5 or earlier ICs or would involve the development of future OMAP chips.

—by Peter Clarke

▷**TI**, www.ti.com.

▷**iRobot**, www.irobot.com.

04.05.12

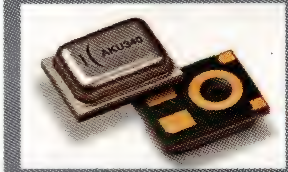
DIGITAL MEMS MICROPHONE TARGETS SMARTPHONES

Akustica's new two-chip AKU340 microelectromechanical-system microphone uses CMOS technology from Bosch, which acquired Akustica in 2009. The AKU340 measures 2.5×3.35×1 mm, offers a typical 63-dB signal-to-noise ratio, and features low-frequency recording with a reduction in sensitivity of less than 5 dB at 50 Hz. Sensitivity matching between microphones is ±2 dB for microphone arrays in which the use of more microphones yields better performance.

Operating voltage is 1.65 to 3.6V, sensitivity is ±–38 dB, and low-frequency –3-dB point is approximately 55 Hz. Total harmonic distortion at 114 dB is less than 5%, and current consumption at 1.8V is less than 300 µA. With a test signal on V_{DD} of 217 Hz and 100 mV p-p, power-supply rejection is more than 60 dB. Flat-frequency bandwidth is 50 Hz to 20 kHz. The device comes in a metal-lid package and sells for $1.34 (1000).

—by Steve Taranovich

▸**Akustica**, www.akustica.com.



Akustica's new multichip AKU340 MEMS microphone uses CMOS technology from Bosch.

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BY HOWARD JOHNSON, PhD

DC-blocking-capacitor performance

A dc-blocking capacitor, which you commonly apply in series with each data wire in a differential link, can serve many purposes. It can, for example, shift the average dc-bias level of the signal to adapt logic families using different voltage standards. It can protect the transmitter, the receiver, or both from destructive overload events that can happen due to poor power-up sequencing. It can function as part of a circuit that detects when the lines are disconnected. In all of these applications, the dc-blocking circuit must not distort the data passing through it.

Figure 1 illustrates a typical electrical model of a dc-blocking capacitor as you might apply it in series with a serial link. The model shows one PCB-trace input and one output. Physically, the capacitor solders onto mounting pads that connect the input and the output traces. Electrically, the **figure** substitutes for the physical capacitor a schematic comprising the three main elements of the standard electrical model for a capacitor. C_{BULK} represents the nominal capacitance of the component. L_{SERIES} is the layout inductance associated with the pads, vias, and any parts of the capacitor body the signal current traverses. R_{SERIES} is the equivalent series resistance of the component. **Figure 1** lists typical values for a garden-variety, EIA 0402-sized, 6.3V capacitor. The **figure** also includes a fourth element, C_{BODY}. That element represents the parasitic capacitance between the physical capacitor body and all other nearby objects, including the reference planes.

The first step in any circuit analysis involves a quick evaluation of the circuit impedances to see whether you can ignore any elements. Assume a link rate of 6.25 Gbps, for which the frequency of the alternating 101010 pattern, the fastest pattern you can make, equals 3.125 GHz. **Figure 1** lists the impedance magnitudes of the four model elements at that frequency.

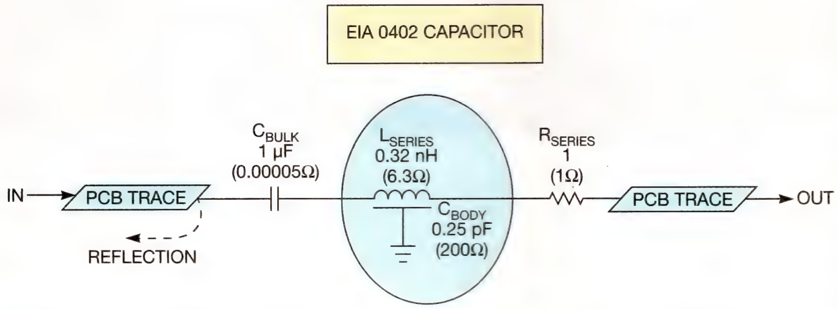

Figure 1 In a dc-blocking capacitor, the impedance magnitudes, in parentheses, at 3.125 GHz of C_{BULK} and R_{SERIES} are negligible. The values for L_{SERIES} and C_{BODY} are the most important.

The impedances of the bulk capacitance and the series resistance are negligible; the series inductance and parasitic-shunt capacitance are the significant elements. The circuit looks like one short section of a ladder-circuit model for a distributed transmission line. The impedance of the circuit equals $\sqrt{L_{SERIES}/C_{BODY}}$, where L_{SERIES} is the series inductance and C_{BODY} is the body capacitance.

When a rising edge arrives at the input terminus, if the circuit has too much body capacitance and too little series inductance, the impedance falls below the PCB's trace impedance, and the circuit reflects a brief negative pulse. If, on the other hand, the circuit has too much series inductance and too little body capacitance, so that the impedance exceeds the PCB trace's impedance, the circuit reflects a brief positive pulse. Adjust the inductance and capacitance to the correct ratio, and the circuit becomes almost completely electrically transparent. That is the secret to exceptional blocking-capacitor performance.

One way to lower the body capacitance is to cut a small, round void in the reference-plane layer right under the capacitor, thus relieving the capacitance to ground and slightly increasing the series inductance. Both effects increase the circuit impedance.

An analog engineer may suggest that you intentionally shrink the value of the bulk capacitance until the frequency of the series resonance formed by the bulk capacitance and the series inductance coincides with 3.125 GHz. Unfortunately, tuning the bulk capacitor in that way gains advantage only in one narrow band and still leaves the parasitic body capacitance to create reflections. Enlarging bulk capacitance until its impedance becomes negligible leaves you with only series inductance and body capacitance to consider. You can balance these elements against each other to obtain almost ideal performance. **EDN**

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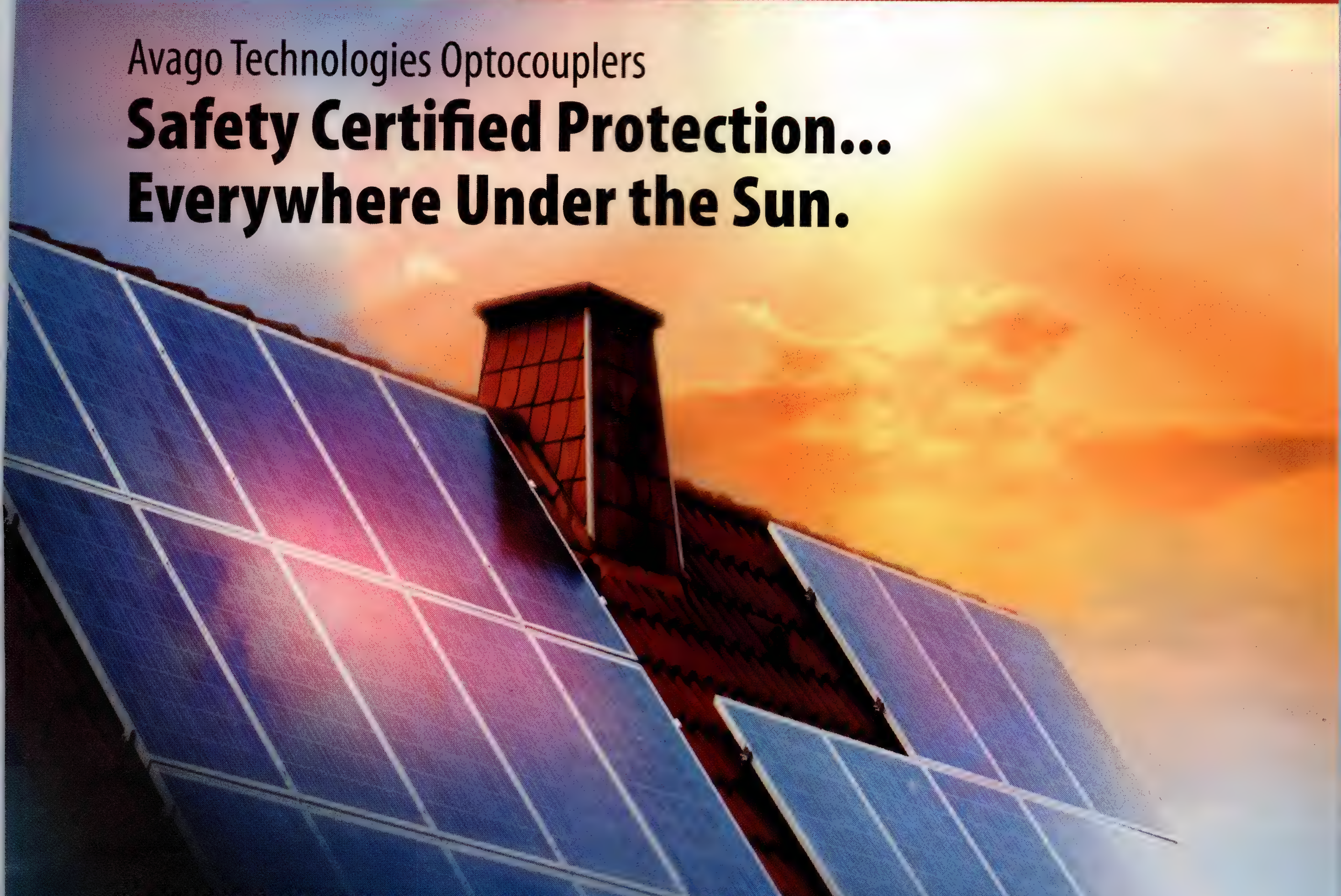

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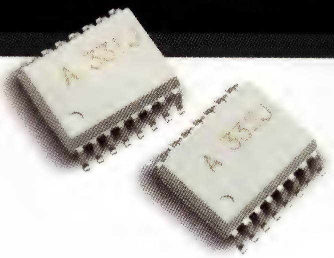

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USE AN OSCILLOSCOPE'S MATH TO MEASURE PARAMETERS THAT YOU CAN'T MEASURE DIRECTLY.

BY DWIGHT LARSON • MAXIM INTEGRATED PRODUCTS

Most engineering labs have digital oscilloscopes, but many engineers don't fully explore their features. Among the more interesting features of a digital oscilloscope is its math channel, which can help you analyze hot-swap and load-switching circuits. Math functions can yield detailed information about hot-swap-circuit parameters that can aid you in design and troubleshooting. For example, you can use an oscilloscope's math functions to calculate load capacitance, which can reveal a MOSFET's transient-power dissipation during start-up or shutdown.

IMAGE: THINKSTOCK

OSCILLOSCOPE SETUP

To give you an idea of how to use math functions, consider the integrated-MOSFET MAX5976 hot-swap device. It combines an internal MOSFET switching element with current-sensing and driver circuitry to form a complete power-switching circuit. The test method also applies to hot-swap control circuits built from discrete components. Connecting oscilloscope probes to the hot-swap circuit in **Figure 1** gives the oscilloscope access to the signals you need for calculations. Voltage probes connect to the circuit's input and output, providing the voltage drop across the MOSFET. A current probe offers the easiest way to sense load current through the device.

The same basic connections apply for a nonintegrated hot-swap circuit. Connect the input and output voltage probes before and after the MOSFET. These probes are inside the MAX5976 but outside the MAX5978. Place the current probe in series with the circuit's current-sense resistor. To get an accurate measure of current flowing through the switch element, place the current probe after the input bypass capacitor and before the output capacitor. The probe must measure the current that passes through the controller. Capacitors C_{OUT} and C_{IN} cannot be between the controller and the current probe.

AT A GLANCE

- Digital oscilloscopes' math channels can help you analyze hot-swap and load-switching circuits.
- The integrated-MOSFET MAX5976 hot-swap device combines an internal MOSFET switching element with current-sensing and driver circuitry to form a complete power-switching circuit.
- Select the oscilloscope probes so that V_{DS} is the difference between Channel 2 and Channel 1 and measure the drain current with the current probe.
- A resistive load degrades the accuracy of these capacitance measurements by drawing current that isn't stored in the capacitor. For short measurements, however, the results can still be useful.

MOSFET POWER DISSIPATION

Power dissipation in the switch element—typically, an N-channel MOSFET—is the product of V_{DS} (drain-to-source voltage) and I_D (drain current). Select the oscilloscope probes so that V_{DS} is the difference between Channel 2 and Channel 1 and measure the drain current with the current probe. The oscilloscope in this example, a Tektronix DPO3034, has a math trace that you configure through an advanced-math menu.

To measure the MOSFET's power dissipation, simply enter an equation that subtracts Channel 1 from Channel 2 and multiply the result by the current-probe signal. When the hot-swap circuit is enabled, its output voltage rises toward the input potential at a particular dV/dt slew rate. The load-capacitance charging current flows

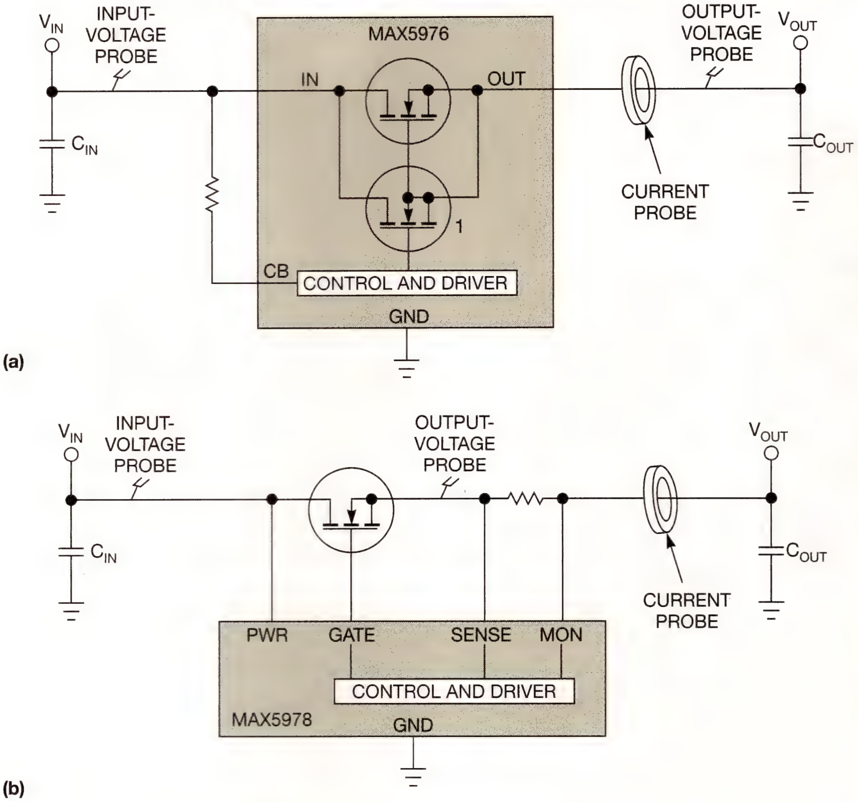

Figure 1 Connect voltage probes across a MOSFET to measure V_{DS} (a) and a current probe to measure I_D (b).

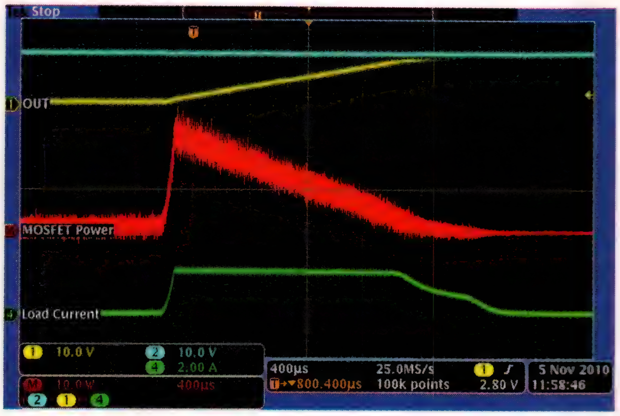

Figure 2 The MOSFET power dissipation for the circuit of Figure 1 (middle trace, red) for C_{OUT} is 360 µF. The hot-swap device limits inrush current to 2A.

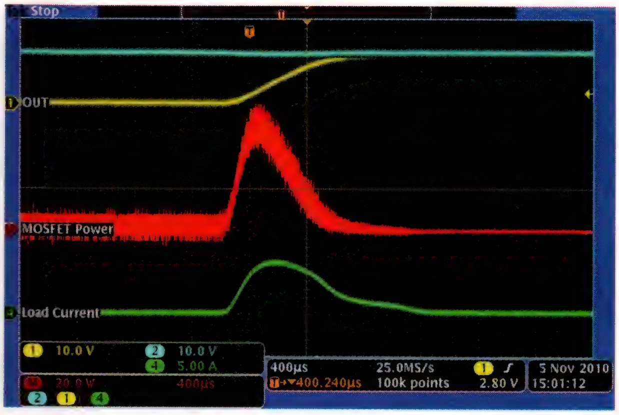

Figure 3 During start-up, neither the voltage (top trace, yellow) across, V_{DS}, nor the current (bottom trace, green), I_D, through the MOSFET is constant.

through the MOSFET according to the following **equation:** $I_D=C_{OUT}\times(dV/dt)$.

Capturing this start-up event on the oscilloscope yields the waveforms in **Figure 2**, for which output capacitance is 360 µF and input voltage is 12V. The hot-swap device limits inrush current to 2A. Note that the power waveform is a decreasing ramp, starting at 24W (12V×2A) and falling to 0W as the output rises to 12V, given a constant current charging the load capacitance, C_{OUT}.

A CURRENT PROBE OFFERS THE EASIEST WAY TO SENSE LOAD CURRENT.

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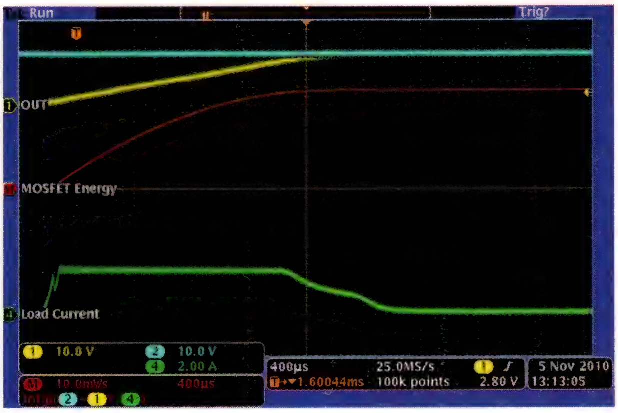


Figure 4 Integration of power dissipation yields the total energy deposited in the MOSFET.

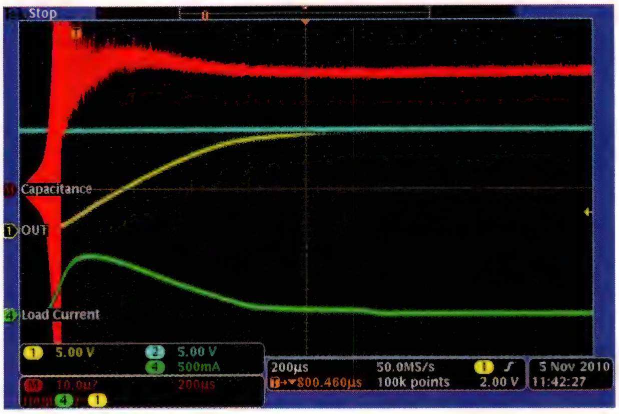
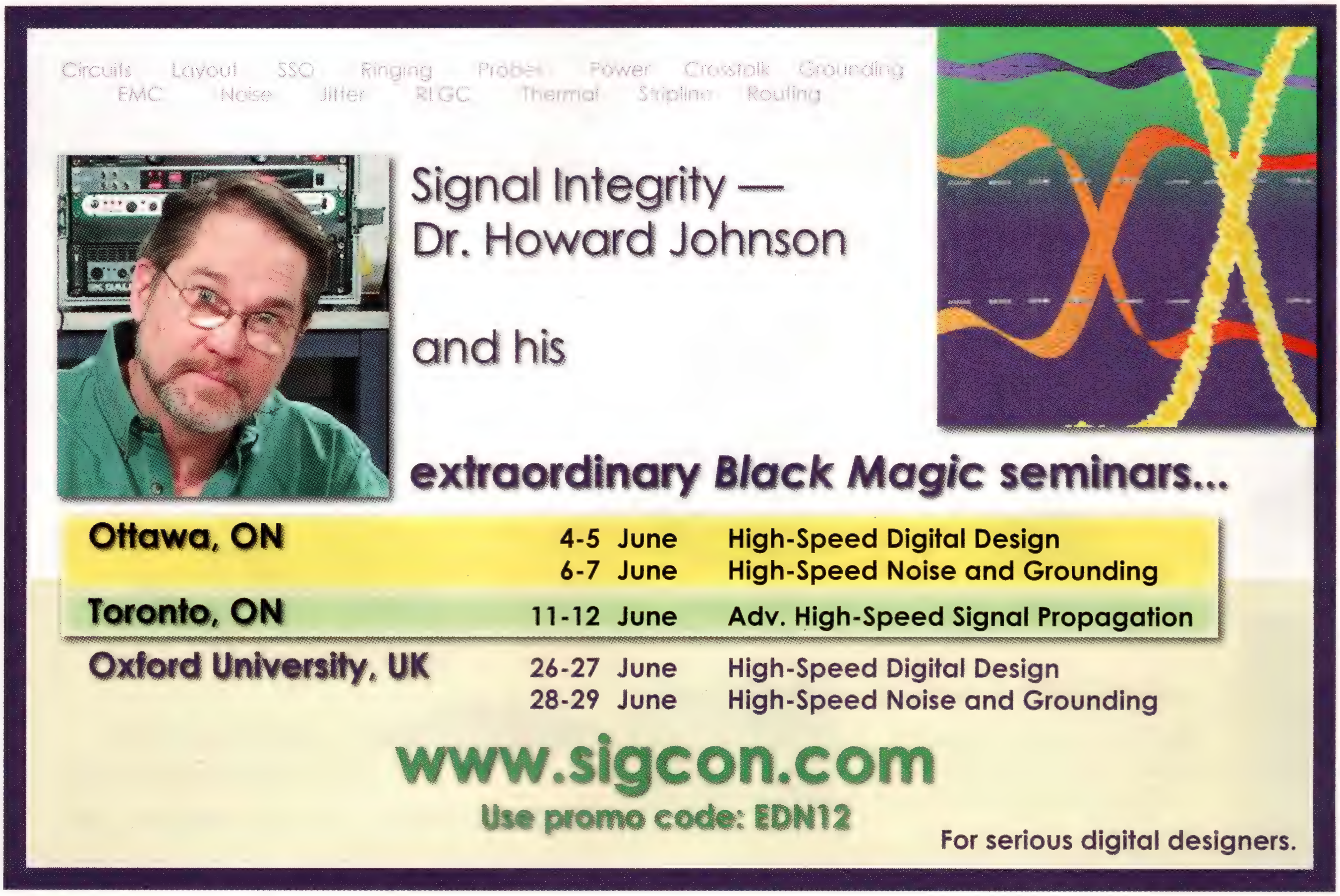


Figure 5 The output-capacitance measurement shows that C_{OUT} is 30 µF.

rise in junction temperature by referring to relevant charts in the MOSFET's data sheet. Calculating the power waveform directly from actual voltage and current measurements eliminates the error inherent in making an approximation of power dissipation. What's more, you can accurately capture the power waveform during a start-up event, when neither the inrush current nor the dV/dt is constant (**Figure 3**). C_{OUT} is 360 µF, and the inrush current is clamped to 2A.

If your oscilloscope's math functions include integration, you can take the waveform calculation one step further. Integration can show the total energy deposited in the MOSFET during an event. **Figure 4** applies the integration function to the MOSFET's power information. Because the power waveform has a triangular shape with a start-up of approximately 2 msec, you can expect approximately 24W/2×2 msec=24 mJ of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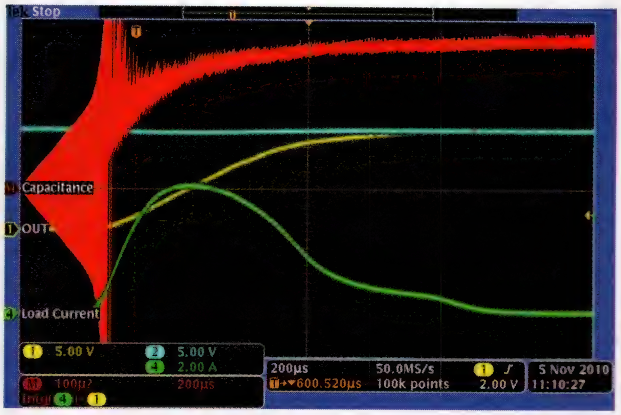

Figure 6 Adding a 330-μF capacitor produces a measured output capacitance of 350 μF.

YOU CAN USE AN OSCILLOSCOPE'S INTEGRATION FUNCTION TO MEASURE HOT-SWAP LOAD CAPACITANCE.

energy, which converts to heat in the MOSFET. The math channel's integral of power reaches almost exactly 24 mJ of energy at the end of the start-up event.

You can apply this technique to other transient conditions that affect the MOSFET, such as shutdown, short-circuit, or overload events. Such detailed power-and-energy information lets you make precise calculations of pulse duration and "single-pulse power" when checking the MOSFET's safe operating area and thermal characteristics.

MEASURE LOAD CAPACITANCE

You can also use an oscilloscope's integration function to measure hot-swap load capacitance, provided that the resistive-load current is small during start-up. Capacitance is the amount of charge stored per volt applied to a capacitor, and charge is simply the time integral of current. So, by integrating the hot-swap inrush current and dividing by the output voltage, an oscilloscope's math function can accurately measure the total load capacitance.

The hot-swap controller in **Figure 5** connects to three ceramic output capacitors, each with a nominal value of 10 μF. The capacitance trace (red) is initially meaningless because of the divide-by-zero problem that occurs before the output voltage rises. When the output voltage exceeds 0V, however, the math channel quickly converges to a measured capacitance of approximately 27 μF. The scale is 10 μF/division.

Figure 6 repeats the experiment of **Figure 5**, but with an additional aluminum electrolytic capacitor of nominal value 330 μF added to the output. As the start-up event ends, the math trace shows a measured output capacitance of approximately 350 μF—almost exactly what you'd expect. The scale is 100 μF/division.

Remember that a resistive load degrades the accuracy of these capacitance measurements by drawing current that isn't stored in the capacitor. For short measurements, however, the results can still be useful.EDN

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AUTHOR'S BIOGRAPHY

Dwight Larson is a senior member of the technical staff at Maxim Integrated Products. He received a bachelor's degree in electrical engineering from the University of Houston and holds four patents. Larson served in the US Navy from 1985 to 1991 as a submarine nuclear-reactor mechanic and radiological-controls technician.

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BY *EDN* STAFF

The UBM Electronics ACE (Annual Creativity in Electronics) Awards combine *EDN*'s Innovation Awards and *EE Times*' ACE Awards and are among the few chances for us to honor the best of the best individuals, teams, teachers, mentors, innovators, products, technology, and creativity that propel our industry forward. Along with the usual awards, devoted to products, design teams, start-ups, companies, executives, and lifetime achievement, we have added a few more categories over the past several years, including Student of the Year, and, for 2011, we've added Mentor of the Year and Contributor of the Year as special recognition for those engineers or teachers who exemplify the best of what it means to be a true participant in and contributor to the engineering profession. The inaugural Contributor of the Year Award goes, posthumously, to long-time *EDN* contributing writer and industry guru Jim Williams, after whom we have named the award. We hope you can join us in celebrating this year's winners online at www.edn.com/120405cs, where we show the event as it unfurled at this year's Design West conference. Congratulations to all of the winners.

DESIGN TEAM OF THE YEAR: TILERA'S TILE DESIGN TEAM

Patrick Mannion, *Director of Content*

The Design Team of the Year Award goes to a group of innovators whose collaborative efforts made a significant contribution to the evolution of technology and whose project-management abilities are creative, efficient, and inspiring. It's a high bar, yet there were many worthy candidates in 2011. Still, one group stood out sufficiently to take the top spot: Tilera's Tile-architecture design team.

Emerging in 2005, the Tile architecture comprises 16 to 100 identical cores, connecting through the use of a nonblocking switch and a 2-D on-chip mesh network, or tile. Each comprises a complete processor and L1 and L2 cache with a Dynamic Distributed Cache architecture to accelerate coherent cache performance.

Tilera's approach eliminates the bottlenecks and consequently the limited scalability and performance of on-chip bus interconnects. The tiles are in a checkerboard fashion with full-featured SOC functions, such as memory and I/O controllers around the perimeter of the chip, eliminating the need for a separate north- and south-bridge chip set.

As with all new architectures, easy-to-use tools and a familiar programming environment are critical. With those criteria in mind, Tilera's team designed Tile with a standard ANSI C and C++ programming environment to allow developers to use their software investment as well as the vast body of available open-source code. Tiles can be grouped into clusters to apply the appropriate amount of computational

horsepower to each application.

Building Tile required just 42 engineers rather than hundreds, and those 42 have since 2005 laid out 1.2 billion transistors, or approximately 66 million transistors per person—probably

IMAGES: THINKSTOCK

an industry record. To make it happen, the company picked the best of the best, with a team comprising members from Broadcom, Intel, AMD, and Digital Equipment Corp, along with graduate students from MIT.

From the onset, Tilera's headquarters were in California, and its development team was in Massachusetts. Although this arrangement resulted in a lot of travel time for the chief executive officer, it benefited the company in many ways. These benefits include the establishment of a uniform culture, communication style, and remote-collaboration method across a geographically distributed organization. The arrangement has served the company well; it has since grown to numerous worldwide locations.

With the design and development taking place in the Boston area, Tilera was immersed in a rich heritage of companies focusing on processor development and able to hire a combination of proven industry veterans and young, vibrant students from MIT. The downside of that arrangement was that the nine perennially hungry graduate students managed to consume an entire month's worth of office snacks in one day and tied up the office's one bathroom by using the previously unused shower. The team worked in an office provided by its Bessemer Venture backers, but PA Semi had arrived first at the Bessemer facility and staked claim to the choice "parlor." The Tilera team was left to start building the world's most advanced microprocessor technology on the porch and in the sun room, in the summertime, with no air-conditioning.

So, for innovation, dedication, collaboration, ingenuity, and perseverance under trying circumstances, this year's Design Team of the Year Award goes to Tilera, led by John Brown, vice president of IC engineering, and Richard Schooler, vice president of software engineering and applications.

INNOVATOR OF THE YEAR: MICHAEL McCORQUODALE

Patrick Mannion

The Innovator of the Year Award goes to the individual who brings leadership, creativity, and out-of-the-box thinking to technology, a product, or a business, and this year's winner is no exception. Two truisms come to mind when thinking about Michael McCorquodale, general manager of the silicon-frequency-control business at Integrated Device Technology. The first: If you want to be successful, find a big problem and solve it. The second: If you want to get engineers to do something, tell them it can't be done—or that you think one of their peers can do it better.

Michael McCorquodale has taken on CMOS challenges for his entire 14-year career.

In the case of the first truism, McCorquodale picked a doozy, one that has occupied his entire 14-year academic and professional career. He chose to focus on replacing mechanical quartz crystal oscillators with all-silicon CMOS oscillators that are neither mechanical nor MEMS-based and are manufactured entirely in standard CMOS technology. The primary obstacle to all-CMOS oscillators is silicon's lack of high-frequency accuracy or stability, due to manufacturing variances and high-temperature sensitivity. Still, the advantages of all-CMOS oscillators—versus using an external device—are manifold and attractive. They include lower cost and the integration of on-chip oscillators with timing controllers. Typical quartz-based frequency-control devices need to be assembled in temperature-stable ceramic packages with CMOS circuitry.

When trying to solve this big problem, McCorquodale had many naysayers. Most industry experts considered the feat impossible, and engineers largely abandoned it in the 1960s. Since then, quartz-based frequency references have become ubiquitous, with manufacturers shipping more than 10 billion units—and represent one of the final holdouts for integration into silicon.

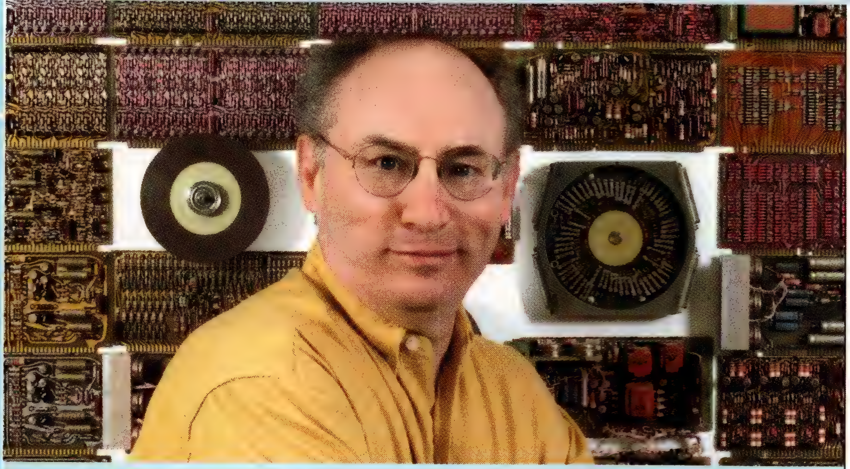
Despite this tide of negativity, including tight-fisted venture capitalists working with previous assumptions, McCorquodale didn't waver. In 1998, he took the opportunity to use advances in RF-CMOS technology and revisit the performance capabilities of CMOS oscillators. The next 14 years of work included six years of academic research as well as five years of commercial-development efforts at the start-up he founded, Mobius Microsystems.

By then, teams with decades of experience had founded several MEMS companies. Meanwhile, McCorquodale struggled to build a team, raise capital, and gain market traction. Most experts considered the technology unfeasible, so there was little interest. Nevertheless, his persistence enabled him to raise modest capital, and he finally realized his vision at Mobius.

IDT purchased Mobius in January 2010; IDT saw it as a natural fit for its vision of equipping every digital system with an interface employing IDT silicon. The company is currently the leader in silicon-timing devices that translate and synchronize timing signals originating from quartz- or silicon-based frequency references.

At IDT, McCorquodale continues to spearhead further innovations that are leading to the emergence of additional CMOS-oscillator products, realizing the low-cost promise of gross margins in excess of 90% at the same price at which quartz devices achieve 30% or less. Dramatically expanding its served market, IDT is now in a position to finally merge its silicon-timing products with McCorquodale's CMOS oscillators to enable all-silicon timing devices that require no external quartz crystals.

Today, CMOS oscillators are replacing quartz devices in volumes in excess of tens of millions of units a month and achieve performance levels no one ever believed possible. Without McCorquodale's vision, his continuous innovation to realize that vision, unwavering persistence, and leadership in the face of decades of thinking to the contrary, CMOS oscillators would not exist today and would not be transforming the industry.



Analog guru Jim Williams was the consummate contributor, for both his content and the spirit in which he contributed it.

CONTRIBUTOR OF THE YEAR: JIM WILLIAMS

Margery Conner, *Senior Technical Editor*

The category of Contributor of the Year is a new one for the ACE Awards, and its intent is to recognize the accomplishments of the people behind the extraordinary contributions to *EDN* and *EE Times* over the past year. Their work has broadened our understanding of the rapid advances in engineering and design and has inspired countless engineers to reach ever higher. With this goal in mind, we award the inaugural honor, posthumously, to Jim Williams, the consummate contributor, for both his content and the spirit in which he contributed it.

Williams was a superb analog-circuit designer—one of the best. Behind his knowledge of analog-circuit behavior was his ability and desire to explain these circuits and to inspire others with the marvels that analog circuits could perform. For him, circuit design was an art form. Williams' first article for *EDN* appeared in 1975, and his articles immediately became a source of information and inspiration for circuit-design engineers, continuing through 2011 with his last two articles appearing after his death in June.

In a popular blog, "Reading Jim Williams," Kent Lundberg pays tribute to the 62 application notes Williams wrote for Linear Technology (**Reference 1**). Lundberg comments on Williams' circuit-design decisions and includes his "remarkable quotes." Most of us think of application notes as vendors' commercials for their products. Williams, on the other hand, approached all of his writings, whether application notes or contributed articles, as teaching moments. He ended one of his app notes with a paraphrase of Einstein: "Everything should be as simple as possible, but not too simple."

As former *EDN* Technical Editor Paul Rako said of Williams' writing (**Reference 2**), "[His] articles always stressed understanding. Jim did not condescend and write down to us. He never tried to impress you with his math or his intellect. He didn't make things complicated so you would think he was smart. He made things look simple. That [ability] is why he was brilliant. Anyone can learn a bunch of jargon and a few tricks and secrets and try to act smarter than you. Jim was the exact opposite. He took the trouble to describe the basic principles of what was going on. Then he showed you how to achieve the goals your designs needed to achieve."

For these reasons, Williams is the first winner of the Contributor of the Year Award, which we have renamed the "*EE Times*/*EDN* Jim Williams Memorial Contributor of the Year Award." In this way, Williams will always symbolize what contributing to the engineering community is all about.

REFERENCES

1 Lundberg, Kent, "Reading Jim Williams," http://bit.ly/z6YgEE.

2 Rako, Paul, "Analog guru Jim Williams dies after stroke," *EDN*, June 13, 2011, http://bit.ly/jisUbW.

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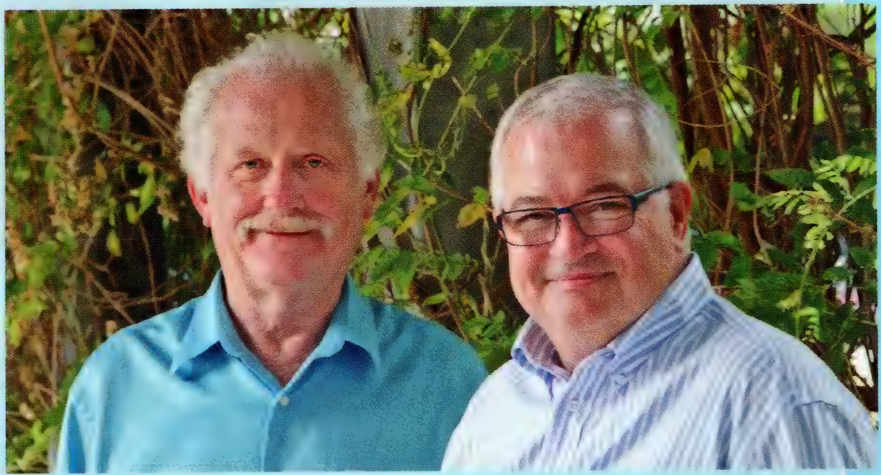

James Truchard (left) and Jeff Kodosky launched LabView's modular approach.

By definition, the *EE Times/EDN* Lifetime Achievement Award goes to an individual or individuals whose contributions over a career in electronics have had a demonstrable effect on technological, business, and cultural advancements. This year's winners, James Truchard, PhD, and Jeff Kodosky, co-founders of National Instruments, epitomize the spirit of the award.

Since founding NI in 1976 while working at the University of Texas—Austin, both Truchard and Kodosky have remained fully involved in the company, although from different vantage points. (A third co-founder, William Nowlin, has since left.) Truchard took on the role of president and chief executive officer, and Kodosky remained as a hands-on presence, now serving as a mentor in the company's global R&D organization. Still, both manage to infect everyone at NI with their own passion, humor, and love of technology and design enablement.

As anyone who has ever attended the company's annual NI Week celebration can testify, the enthusiasm and affinity for the company and its products have no precedent in the technology arena—and for good reason. National Instruments in 1986 launched LabView and its modular approach to hardware. The product has helped NI pioneer the development of virtual-instrumentation software and hardware that has revolutionized the way engineers, academicians, and novices design and develop measurement and automation applications.

Since 1976, NI has grown into a multinational organization with more than 6100 employees. Still, Truchard leads the company with the same entrepreneurial, innovative mindset that led to its inception 36 years ago and passes that approach along to the NI team, making NI one of the top 25 companies to work for, according to the Great Place to Work Institute. *Worth* magazine for three consecutive years named Truchard one of the nation's 50 best chief executive officers, emphasizing his focus on long-term growth and innovation. In the meantime, he still remains involved in many community organizations and is an active supporter of the NI academic program, which focuses on increasing students' STEM (science/technology/engineering/math) skills through hands-on, project-based learning.

Engineers and scientists worldwide revere Kodosky as the father of LabView because he invented the graphical programming language that defines the software. Since the initial release of LabView in 1986, Kodosky has earned 68 patents associated with the technology. His expertise has helped guide LabView development and expansion to targets such as FPGAs, smart sensors, microcontrollers, and other embedded devices previously out of reach for many engineers. Kodosky's ongoing work has helped NI hone this software into an award-winning industry-standard programming environment that has garnered more than 100 national and international industry awards from major industry publications, including *EE Times*, *EDN*, and *Test & Measurement World*.

According to Truchard and Kodosky's philosophy, LabView has been inspiring the next generation of students to pursue careers in engineering and science. Universities are adopting the software to help teach engineering disciplines, including mechatronics, robotics, and communications. For example, it powers the Lego Mindstorms NXT and Lego Education WeDo robotics kits.

"Over the years, we've developed a world-class corporate culture and product portfolio that make National Instruments one of the world's most progressive multinational companies," says Truchard. "Using the NI platform, engineers can design, prototype, and test smarter, more advanced products and technologies to solve our most pressing challenges."

OTHER ACE AWARD WINNERS INCLUDE:

- **Start-up of the Year: mCube**
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- **Energy Technology Award: Maxim Integrated Products**
- **Most Engaged Community Member: Jonathan Chan**
- **Best Student Design/Design Challenge with Public Schools: Oak Canyon Junior High team from Lindon, UT (Pipe Dreams Christmas Tree); Ted Hansen, teacher; Wayne Rust, team mentor**
- **Integrated Program of the Year: Avnet Express Drive for Innovation**

MENTOR OF THE YEAR: STEWART CHRISTIE

Suzanne Deffree, *Managing Editor, Online*

Stewart Christie, using robots, finds mentoring fun and rewarding for both mentors and students.

There's a good chance you've seen Stewart Christie, product-marketing engineer for the intelligent-systems group at Intel, at a recent trade show. If you did see him, it's likely he had a robot with him. Christie is the first recipient of the Mentor of the Year Award, which made its premier at this year's ACE Awards ceremony. The award came about in recognition of those engineers and executives who take action to inspire and encourage the STEM (science/technology/engineering/math) leadership of tomorrow.

Christie learned that he had been named Mentor of the Year while he was attending Embedded World 2012, fittingly the evening before Student Day, when 1000 highly motivated, final-year engineering-degree students attend the show. Christie participated, just as he has in many next-generation STEM events—from elementary-school science fairs to hacker spaces to mentor/student-networking events to design competitions, including this spring's Cornell Cup, a college-level embedded-design competition. Intel and Tektronix sponsor the contest, which gives teams the opportunity to win as much as $10,000. The semiconductor-industry veteran acts as a mentor and an advisor for that competition.

Robotics, as they do in many next-generation STEM efforts, play an important part in Christie's activities. "Robots are good crowd-pleasers for students," he says. "The robots themselves are often developed by students and university-research projects. It's much easier to get students interested in something, make it fun, and then make them realize later on that they have to do math and engineering if they want to learn more about it."

Christie notes that mentoring is part of the Intel corporate culture. "I do it because it's fun, but it's really rewarding, as well," he says, adding that mentoring is a two-way street. If mentors listen, they can also learn something from their students. "Learning is a lifelong thing," he explains. "I'd love to go back to university, but at least I can keep learning new things. Mentors and teachers are continually important. I think once I've learned everything, I'll be fine and won't need a mentor … so it's going to be a while."

STUDENT OF THE YEAR: AARON GOLDSTEIN

Suzanne Deffree

When we contacted Aaron Goldstein to congratulate him on being named the ACE Awards Student of the Year, the 22-year-old Arizona State University senior repeatedly said, "I'm really excited," but he wasn't speaking only of the award. In May, Goldstein will receive his undergraduate degree in aerospace engineering with a concentration in aeronautics. Goldstein began gathering real-world engineering experience in June 2009 after his freshman year at ASU when he took an internship at General Dynamics Advanced Information Systems in the satellite-systems-engineering department. During that year, Goldstein assembled a group of undergraduate students to compete in a deep-space-mission design competition.

Aaron Goldstein began gathering real-world experience as an intern.

The following year, Goldstein continued his internship as Orbital Sciences Corp acquired General Dynamics. In August 2010, Goldstein again gathered a group of undergraduate students with a focus on designing and building space satellites and founded the Sun Devil Satellite Laboratory with a handful of fellow ASU students.

Understanding both the value and the challenges of collaboration, Goldstein values his peers as much as he values those who have helped guide his early career. "It's difficult finding a good mentor to help foster your skills and to ask advice, but there are people out there who help," he says. "But the most difficult part is being able to find other friends or students who are motivated like that."

The Sun Devil Satellite Lab effort led to a successful preconcept-design review of an earth-imaging satellite. In 2011, the Sun Devil Satellite Lab attracted the attention of a solar-science research team at NASA's GSFC (Goddard Space Flight Center). The NASA research team and Goldstein's Sun Devil Satellite Lab collaborated and began a joint effort, the Sun Devil Satellite 1 mission. Goldstein and his team have since led the Sun Devil Satellite 1 spacecraft through successful preliminary- and critical-design reviews. Taking notice of Goldstein's skills, NASA in 2010—and again in 2011—awarded him a Space Grant internship. With the second award, Goldstein remained a research intern but was promoted to a student advisory/leadership role.

Goldstein plans to continue working at Orbital Sciences after he graduates next month. He has other plans, as well. With well-matched engineering-spirit and entrepreneurial goals, along with a supportive family, Goldstein plans to start an aerospace and electrical-engineering design company. "[I and] a few of the other students I work with at the satellite lab think it would be cool if we could do this [project] and make some money at it or at least be able to do it on our own terms," he says. "We want to do more than just [work with] satellites and more than electronics and aerospace applications."

Goldstein will be spending the next few weeks leading up to his graduation looking for support for his start-up and planning funding and grants proposals for the satellite lab. "There's quite a bit in store," he says. "I'm really excited. I keep using that word, but it's the only word I can use to explain how I feel right now. It's exciting."

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ULTIMATE PRODUCTS

Rich Pell, *Executive Editor*

Junko Yoshida, editor-in-chief of *EE Times*, describes the ACE Awards program as an opportunity to recognize "the technologies that have made a difference in the way we work, live, and play." Nothing exemplifies this idea better than the winners of this year's ACE Awards for Ultimate Products.

In the "work" category, you'll find tools such as a virtual-prototyping platform and a mixed-domain (frequency/time) oscilloscope that simplify and advance engineering design and test. The winners also include a digital temperature sensor and CMOS oscillator that help the portable devices you use every day perform their best, as well as several design platforms that address automotive infotainment, human-interface technology, and home telehealth applications. The winners also include a "play" category. In this section is a USB-microcontroller family, which, among other things, is ideal for use in low-bandwidth-communication applications, such as game controllers.

DIGITAL ICs: LPC11U00 MICROCONTROLLERS (NXP SEMICONDUCTORS)

Available 8-bit microcontrollers have traditionally supported USB-to-serial applications, but the Cortex-M0-based LPC11U00 microcontrollers from NXP, which feature a highly configurable full-speed USB 2.0-device controller, up the ante by offering more performance and better code density and maintaining lower power at a lower cost.

By offering integrated USB-class drivers in on-chip ROM, the devices can maximize flash-memory efficiency, save as much as 16 kbytes of code space, and provide fully tested and easy-to-use APIs to speed USB integration. The LPC11U00 can enable maximum USB performance by providing as many as 10 configurable physical endpoints with flexible user-defined buffer-architecture management, faster postprocessing of USB data, and robust asynchronous USB operation. The LPC11U00 family is available in 4.5×4.5-mm TFGBGA-48 packages, with as much as 128 kbytes of flash memory and as much as 4 kbytes of EEPROM.

SOFTWARE: VIRTUAL SYSTEM PLATFORM (CADENCE DESIGN SYSTEMS)

Until recently, to test the software components of a design, software teams would either have to wait until the register-transfer level was complete to run any software, which was too slow for the execution of any meaningful amount, or have to wait to debug the software until after shipping the first silicon—too late to participate in the design process. To address these challenges, Cadence's Virtual System Platform allows software execution at speeds close to real time on an abstract model of the hardware, often available long before the completion of a design. Software teams can use the platform as their application-development platform.

The platform employs SystemC TLM 2.0 and IEEE 1666 standard; supports third-party-processor models, including ARM Fast Models and Imperas OVP models; supports third-party software debuggers; and scales from single-core to multicore software development and debugging with performance reaching hundreds of megahertz.

TEST-AND-MEASUREMENT SYSTEMS AND BOARDS: MDO4000 MIXED-DOMAIN OSCILLOSCOPE (TEKTRONIX)

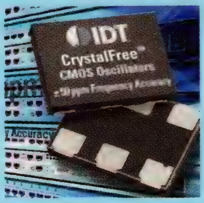
As a result of the increasing use of wireless technology, more than 60% of oscilloscope users also use a spectrum analyzer to troubleshoot embedded designs with wireless functions. The MDO4000 mixed-domain oscilloscope addresses this design trend. Offered as the industry's first oscilloscope with a built-in spectrum analyzer, it combines both the time and the frequency domains in one screen, enabling engineers to quickly and efficiently move between the two domains.

The MDO4000 enables users to capture time-correlated analog, digital, serial, and RF signals with one instrument and is a capable tool for debugging embedded designs with RF. Its built-in, dedicated spectrum-analyzer channel has 50 kHz to 3 or 6 GHz of frequency coverage and at least 1 GHz of capture bandwidth—100 times wider than that of a typical spectrum analyzer.

ANALOG ICs: 3LG FAMILY OF CRYSTAL-FREE CMOS OSCILLATORS (INTEGRATED DEVICE TECHNOLOGY)

Traditional quartz-based oscillators are feeling the strain as CMOS devices operate with less power, comparable or better accuracy and stability, and greater shock and vibration resistance, along with standard, low-cost packaging. The IDT 3LG family, in a quartz-standard footprint, provides guaranteed 50-ppm lifetime frequency accuracy along with a variety of interface compatibilities, such as LVDS, LVPECL, and HCSL.

The new devices replace traditional quartz-crystal-based oscillators for a power savings of as much as 75% in a broad range of applications requiring a 50-ppm timing reference, including computing, communications, and consumer markets. They generate stable frequencies as high as 125 MHz and offer phase jitter of less than 1 psec over a frequency offset of 12 kHz to 20 MHz.



POWER: LTC6803 MULTICELL BATTERY-STACK MONITOR (LINEAR TECHNOLOGY)

Close monitoring of cell potentials in multicell, high-voltage battery stacks, such as those in electric and hybrid-electric vehicles, high-power portable equipment, and backup-battery systems, presents major challenges in basic instrumentation and safety. Linear Technology's LTC6803 family of multicell battery-stack monitors eases that challenge. The devices combine the requisite functional blocks and also tolerate high voltages and floating, ungrounded connections. They include 12-bit ADCs, precision voltage references, a high-voltage input multiplexer, and a serial interface. Designers can connect parts in series without optocouplers or isolators to allow the monitoring of every cell in a long string of series-connected batteries.

SOCs: ZYNQ-7000 EPP (XILINX)

The Zynq-7000 EPP (extensible processing platform) offers a unique mix of a high-end, dual-core ARM Cortex-A9 subsystem, including cache, memory controllers, interface, and peripheral functions, with a 28-nm programmable digital FPGA fabric and programmable analog capabilities. After developers profile the code and identify the functions requiring acceleration, hardware-design engineers take over to create custom accelerators in the FPGA fabric.

Ultimately, the Zynq family offers designers a comprehensive platform that enables them to create customized SOCs that scale from very cost- and power-effective products employing the capabilities of the Artix-7 FPGA programmable logic to more comprehensive and performance-oriented products on the higher end with devices employing the Kintex-7 programmable logic.

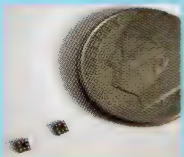
HUMAN-MACHINE-INTERFACE TECHNOLOGY: XTRINSIC CAPACITIVE- AND RESISTIVE-TOUCH-SENSING PLATFORM (FREESCALE SEMICONDUCTOR)

Automobiles, appliances, medical devices, and low-end smartphones can now create inexpensive alternatives to capacitive-touchscreen products by simply upgrading their touchscreen-controller ICs to Freescale Semiconductor's Xtrinsic CRTouch capacitive- and resistive-touch-sensing platform, which enables resistive touchscreens to handle basic gesture recognition.

CRTouch combines four- and five-wire resistive-screen controllers with basic gesture recognition and as many as four capacitive-touch-sensing electrodes. It communicates over UART and I^{2}C communication protocols and comes in a 5×5-mm, lead-free, 32-pin QFN package.

PASSIVE COMPONENTS, SENSORS, INDICATORS, AND INTERCONNECTS: TMP006 TEMPERATURE SENSOR (TEXAS INSTRUMENTS)

The challenge of remotely measuring temperature became easier with the introduction of the TMP006 temperature sensor from Texas Instruments. The single-chip passive IR sensor combines a MEMS thermopile sensor, signal conditioning, a 16-bit ADC, and local temperature and voltage references in a 1.6×1.6-mm monolithic chip.



The TMP006 opens contactless thermometry to markets such as portable and consumer electronics that previously could not use the technology due to the cost and size of traditional thermopile sensors, and it expands the use of thermopiles beyond the industrial and automotive markets.

DEVELOPMENT KITS, REFERENCE DESIGNS, AND SINGLE-BOARD COMPUTERS: HOME HEALTH HUB REFERENCE PLATFORM (FREESCALE SEMICONDUCTOR)

Facing the challenge of providing cost-effective and high-quality care to increasing numbers of recipients, health-care systems will increasingly need to rely on technologies such as wireless connectivity, cloud computing, and smart connected homes. One such technology is Freescale Semiconductor's comprehensive home-health-hub reference platform, which speeds and eases development for emerging telecommunications-health applications.

The i.MX28-based platform provides multiple connectivity options for connecting with commercially available wired and wireless health-care devices and then relays data it obtains from these devices to a smart mobile device, a cloud-based data-management system, or both to track and monitor patients' health status. EDN

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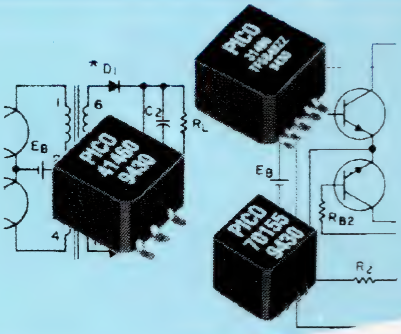

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Look What's Happening at IMS2012!

Plenary Session Speaker: Steve Mollenkopf

President and Chief Operating Officer, *Qualcomm*

3G/4G Chipsets and the Mobile Data Explosion

Monday, 18 June 2012
1730-1900

The rapid growth of wireless data and complexity of 3G and 4G chipsets drives new design and deployment challenges for radio and device manufacturers along with carriers. This talk will provide a perspective on the problem from the point of view of a large, worldwide manufacturer of semiconductors and technology for cellular and connected consumer electronics devices. The increase in device and network complexity will result in significant business opportunities for the industry.

Closing Ceremony Speaker: Thomas H. Lee

Professor, *Stanford University*

The Fourth Age of Wireless and the Internet of Everything

Thursday, 21 June 2012
1700-1830

"Making predictions is hard, particularly about the future." The patterns of history are rarely discernible until they're obvious and perhaps irrelevant. Wireless may be an exception, at least in broad outline, for the evolution of wireless has been following a clear pattern that tempts us to extrapolate. Marconi's station-to-station spark telegraphy gave way to a second age dominated by station-to-people broadcasting, and then to today's ubiquitous people-to-people cellular communications. Each new age was marked by vast increases in value as it enlarged the circle of interlocutors. Now, these three ages have covered all combinations of "stations" and "people," so any Fourth Age will have to invite "things" into the mix to provide another stepwise jump in the number of interlocutors. This talk will describe how the inclusion of multiple billions of objects, coupled with a seemingly insatiable demand for ever-higher data rates, will stress an infrastructure built for the Third Age. Overcoming the challenges of the coming Fourth Age of Wireless to create the Internet of Everything represents a huge opportunity for RF engineers. History is not done.

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BY DANIEL FELDMAN • MICROSEMI CORP

Compliance with POE safety standards is critical when moving beyond 60W

UNDERSTAND THE REALITIES OF SAFELY AND EFFECTIVELY DELIVERING HIGH POWER LEVELS THAT COMPLY WITH THE LATEST POE STANDARD.

The power-over-Ethernet standard offers convenience, flexibility, and enhanced management capabilities by enabling power delivery over the same Category 5 cabling that delivers the data. The current generation of standards-based technology enables the delivery of as much as 60W of power over four pairs of cabling, which also offers better efficiency than that of earlier two-pair approaches.

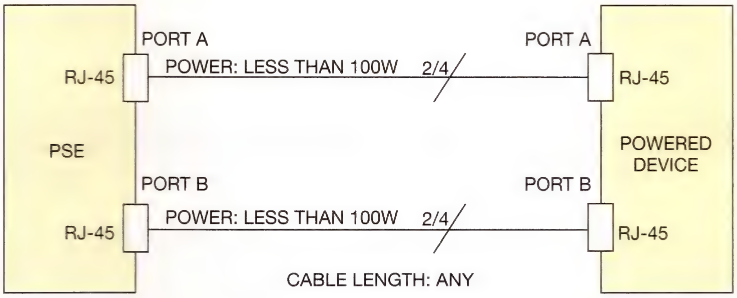
As the industry moves toward delivering even more power over the Category 5-or-better cabling infrastructure, system designers and network administrators must understand various emerging-technology options, including those developed under the auspices of the IEEE, and others that bring expensive and cumbersome deployment complications and, potentially, safety risks. For instance, some manufacturers have touted 100W-per-port approaches that do not perform detection before power-on—a dangerous omission. Others offer 200W/port approaches that are even more dangerous unless they use a hard resettable fuse at every PSE (power-sourcing-equipment) unit or a certified electrician deploys the cables. The only safe approach for powering devices over Ethernet cabling is to follow IEEE802.3at-2009 specifications.

The HDBaseT Alliance is developing 100W power specifications for products that transport uncompressed, high-bandwidth multimedia content, 100BaseT Ethernet, power, and various control signals through a single LAN cable. As a cross-industry organization to promote and standardize whole-home high-definition-multimedia-content distribution, the HDBaseT Alliance has created a "five-play" feature that converges uncompressed, full-HD digital video, audio, 100BaseT Ethernet, IEEE802.3at-compliant power, and various control signals for transmission over a Category 5 cable.

Although independent manufacturers are pursuing approaches to higher power levels, the HDBaseT-powering approach offers other features, including compliance with Section 33.7.1 of the IEEE802.3at-2009 standard, which mandates that all PSEs conform with International Electrotechnical Commission 60950-1:2001 specifications, including classification as a limited power source carrying no more than 100 VA, or 100W, per port without the need for special overcurrent-protection devices. The HDBaseT also performs powered-device detection and classification to determine a device's power consumption before start-up.

Other standards also come into play as the industry moves to higher power. For instance, HDBaseT-powered TV and audio equipment must comply with Underwriters Laboratories 60065, which requires the use of a fire enclosure for loads greater than 15W. Consequently, even if a TV load meets the less-than-100W/port limited-power-source requirement of IEC 60950-1:2011, it still requires a fire enclosure.

Moving beyond the limited-power-source requirement to greater-than-100W/port implementations requires that the cables have a special flame-resistant conduit that attaches



NOTE:
FIRE-METAL ENCLOSURE IS REQUIRED IF POWERED DEVICE'S TOTAL LOAD IS GREATER THAN 100W FOR IT EQUIPMENT OR GREATER THAN 15W FOR AUDIO/TV EQUIPMENT.

Figure 1 This circuit features two ports, each carrying 100W. Power is calculated at the powered-device side, and limited-power-source requirements apply to each port. According to the National Electric Code, multiport midspans that power powered devices using this approach must carry a nameplate with the power rating for each port.

to the PSD and power-device inputs through metal boxes that are enclosed in brackets. This requirement applies to cables longer than 10 feet (3.05m).

For cables shorter than 10 feet, designers can use the same four-pair POE/HDBaseT cabling system comprising a data cable and an RJ-45 connector. The cable must, however, have features exceeding the requirements of typical Category 5/E cable (**Figure 1**). Some manufacturers try to circumvent the 100W ceiling and associated protection requirements by suggesting that the ceiling can apply to each of two PSEs running on two circuits within one cable. Using this logic, they believe that a compliant PSE can support 95W and that a PSE pair can support roughly double that amount on the same cable. This idea is incorrect—and dangerous—however.

The IEEE802.3at-2009 standard specifies that you measure the 100W limited-power-source power ceiling at the physical connector. Tables 2B and 2C of the UL CAN/CSA-C22.2 60950-1-07 and UL 60950-1 documents clearly define restrictions for power sources with and without overcurrent devices (**tables 1** and **2**). The existence of two PSEs on a circuit is irrelevant from a UL point of view because it is an inside-the-box power arrangement that ends at a single connector, which is the only output-power connector and must not exceed 100W.

The only ways of implementing powering at 250W or 250 VA are either to use a circuit breaker or a fuse at each port or to have a certified electrician install the cabling, which effectively negates the deployment benefits of POE technology. **Figure 2** shows the proper configurations for delivering greater than 100W over all wires—for example, 200W—in two single-port scenarios.

Both scenarios require a metal enclosure if the total powered device's load is greater than 100W for information-data equipment or greater than 15W for TV and audio equipment. The scenario in **Figure 2a** requires a nonstandard cabling infrastructure to ensure safety. The approach cannot use RJ-45 connectors directly at PSE and powered-device inputs and requires a certified electrician for installation. The scenario in **Figure 2b** can use a typical POE/HDBaseT cabling system but also requires special cabling. In summary, the use of a standard Ethernet-cabling infrastructure for a single port delivering greater than 100W is simply unsafe under the National Electric Code standard.

FOUR-PAIR DELIVERY

HDBaseT achieves its high-powering capabilities and maintains full standards compliance by using the IEEE802.3at-2009 specification's mechanism for delivering power over all four pairs. Four-pair powering enables greater power delivery with greater efficiency. It gives powered devices two power interfaces so that they can receive twice the power of two-pair approaches by using all four pairs of

TABLE 1 LIMITS FOR POWER SOURCES WITHOUT AN OVERCURRENT-PROTECTIVE DEVICE

Output voltage[a] (U_{OC})			
V ac	**V dc**	**Output current[bd] (I_{SC}) (A)**	**Apparent power[cd] (S) (VA)**
≤30	≤30	≤8	≤100
—	$30<U_{OC}\leq 60$	$\leq 150/U_{OC}$	≤100

a U_{OC}: Output voltage measured in accordance with 1.4.5 with all load circuits disconnected. Voltages are for substantially sinusoidal ac and ripple-free dc. For nonsinusoidal ac and dc with ripple greater than 10% of the peak, the peak voltage shall not exceed 42.4V.

b I_{SC}: Maximum output current with any noncapacitive load, including a short circuit.

c S (VA): Maximum output VA with any noncapacitive load.

d Measurement of I_{SC} and S are made 5 sec after application of the load if protection is by an electronic circuit or a positive-temperature-coefficient device, and 60 sec in other cases.

TABLE 2 LIMITS FOR POWER SOURCES WITH AN OVERCURRENT-PROTECTIVE DEVICE

Output voltage[a] (U_{OC})		Output current[bd] (I_{sc}) (A)	Apparent power[cd] (S) (VA)	Current rating of overcurrent-protective device[e] (A)
V ac	**V dc**			
≤20	≤20	$\leq 1000/U_{OC}$	≤250	≤5
$20<U_{OC}\leq 30$	$20<U_{OC}\leq 30$			$\leq 100/U_{OC}$
—	$30<U_{OC}\leq 60$			$\leq 100/U_{OC}$

a U_{OC}: Output voltage measured in accordance with 1.4.5 with all load circuits disconnected. Voltages are for substantially sinusoidal ac and ripple-free dc. For nonsinusoidal ac and dc with ripple greater than 10% of the peak, the peak voltage shall not exceed 42.4V.

b I_{sc}: Maximum output current with any noncapacitive load, including a short circuit, measured 60 sec after application of the load.

c S (VA): Maximum output VA with any noncapacitive load measured 60 sec after application of the load.

d Current-limiting impedances remain in the circuit during measurement, but overcurrent-protective devices are bypassed. Note: The reason for making measurements with overcurrent-protective devices bypassed is to determine the amount of energy that is available to cause possible overheating during the operating time of the overcurrent-protective devices.

e The current ratings of overcurrent-protective devices are based on fuses and circuit breakers that break the circuit within 120 sec with a current equal to 210% of the current rating specified in the table.

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LINEAR TECHNOLOGY

DESIGN NOTES

60V Buck-Boost Controller Drives High Power LEDs, Charges Batteries and Regulates Voltage with Up to 98.5% Efficiency at 100W and Higher – Design Note 501

Keith Szolusha

Introduction

The LT®3791 is a 4-switch synchronous buck-boost DC/DC converter that regulates both constant-current and constant-voltage at up to 98.5% efficiency with a single inductor. It can deliver hundreds of watts and features a 60V input and output rating, making it ideal for driving high power LED strings and charging high voltage batteries when both step-up and step-down conversion is needed. It can also be used as a constant-voltage buck-boost regulator with current limiting and monitoring for both input and output.

Buck-Boost Controller Drives 100W LED String for Airplane and Truck Lights

Airplanes and big trucks with 24V batteries need powerful, efficient and robust headlights and spotlights. Figure 1 shows a 33.3V, 3A (nine Luminus SSR-90 LEDs) buck-boost LED driver that runs from 15V to 58V input with up to 98.5% efficiency.

The 4-switch synchronous topology drives high power LEDs with minimal switch power loss (and minimal temperature rise). Unlike other topologies, the LT3791 buck-boost can be shorted from LED+ to both LED– and GND and, as a feature, can be programmed to latch off or keep trying to turn back on if the short is removed. Diagnostic output flags report both short-circuit and open-LED conditions.

The solution in Figure 1 features up to 100:1 PWM dimming at 100Hz for accurate brightness adjustment without color shift and analog LED dimming when a PWM oscillator is not present.

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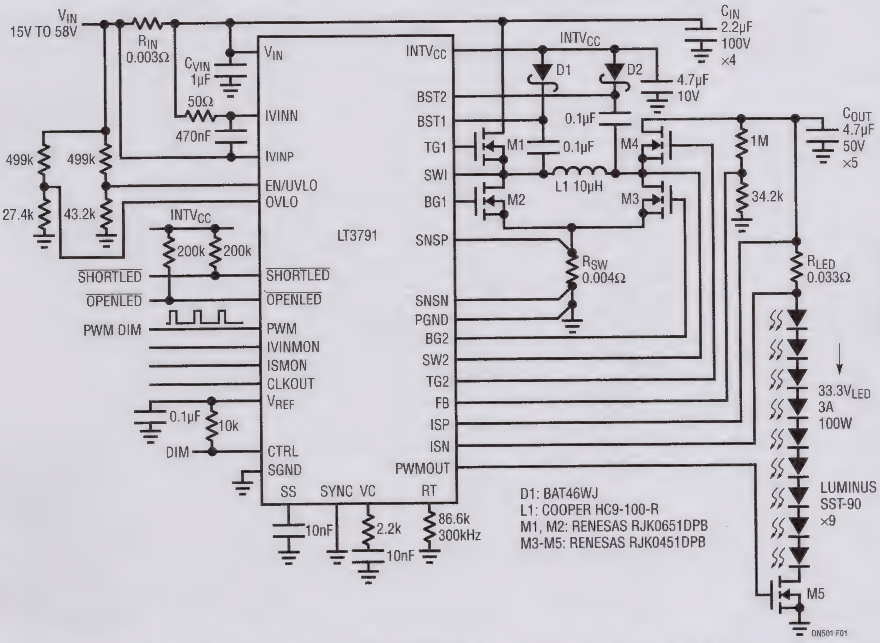

Figure 1. 15–58V$_{IN}$ to 33.3V 3A LED Driver with Up to 98.5% Efficiency

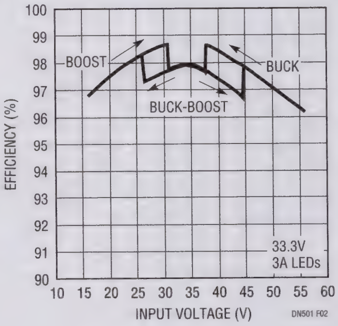

Figure 2. Efficiency of Figure 1

36V, 2.5A SLA Battery Charger

The buck-boost converter shown in Figure 3 charges a 36V 12Ah SLA battery at 44V with 2.5A DC from a 9V to 58V input.

Specially integrated C/10 current sensing and battery voltage detection drops the battery voltage from its charging voltage (44V) to its float voltage (41V) when the battery is near full charge. The $\overline{\text{OPENLED}}$ flag is used to change the state of the charger from charge to float. When the battery voltage drops far enough, voltage feedback returns the charger to its charge state.

The LT3791 can be tailored to charge a range of battery chemistries and capacities from a variety of input sources regardless of the voltage relationship between them. An external microcontroller can be programmed and used to create a maximum power point tracking device to charge the battery from a solar panel. The output diagnostics and dimming input pins make this a simple interface for high power solar panel applications design.

120W, 6V to 55V Voltage Regulator

The LT3791 can also be used in high power constant-voltage buck-boost applications. The FB pin doubles as both the main voltage feedback for the buck-boost, and the overvoltage protection detection and regulation when used as an LED driver. Figure 1 can be easily turned into a 100W voltage regulator with V_{OUT} between 6V and 55V by placing a 100k resistor between the SS and V_{REF} pins to defeat soft-start reset during a fault.

The voltage regulator is short-circuit proof. The $\overline{\text{SHORTLED}}$ flag reports when there is a short circuit on the output. The input current monitor can still be used in constant-voltage regulation to protect any system that is input-current limited. R_{LED} sets the output current limit for short circuit, but can be removed to provide a $\overline{\text{PGOOD}}$ flag using $\overline{\text{OPENLED}}$ by shorting ISP to ISN.

Conclusion

The LT3791 synchronous buck-boost controller delivers 100W and higher power at up to 98.5% efficiency to a number of different loads. The wide, 4.7V to 60V input and 0V to 60V output voltage range make it both powerful and versatile, and its short-circuit capability makes this a robust choice for many applications in potentially hazardous environments. This seemingly limitless IC can be used in applications where a typical buck or boost converter cannot because of the crossover of input and output voltage ranges.

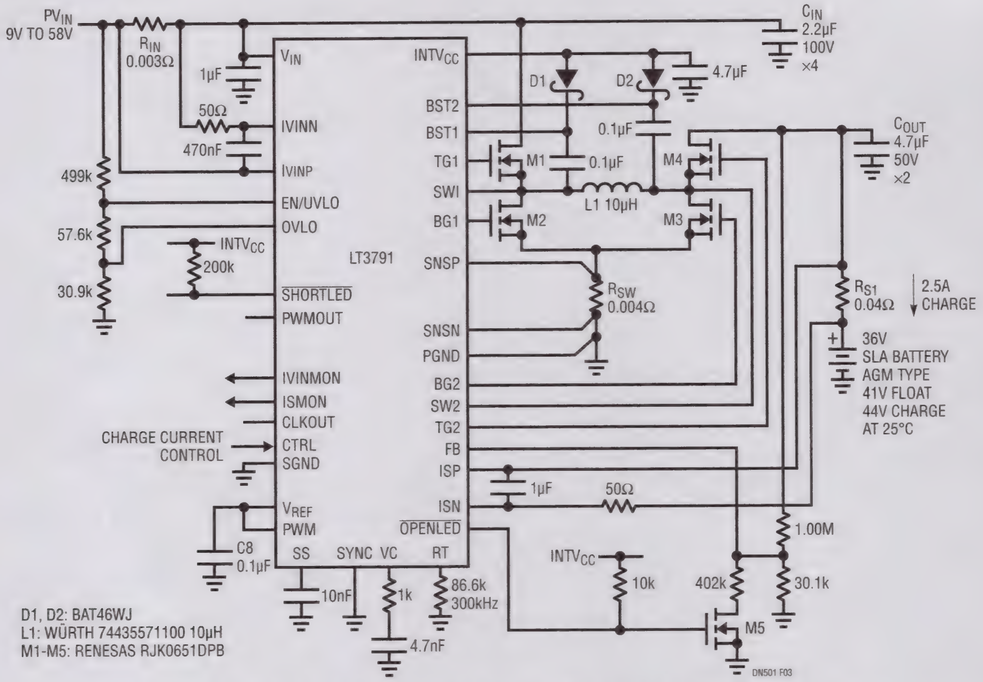

Figure 3. 36V, 2.5A SLA Battery Charger with C/10 Charge Termination

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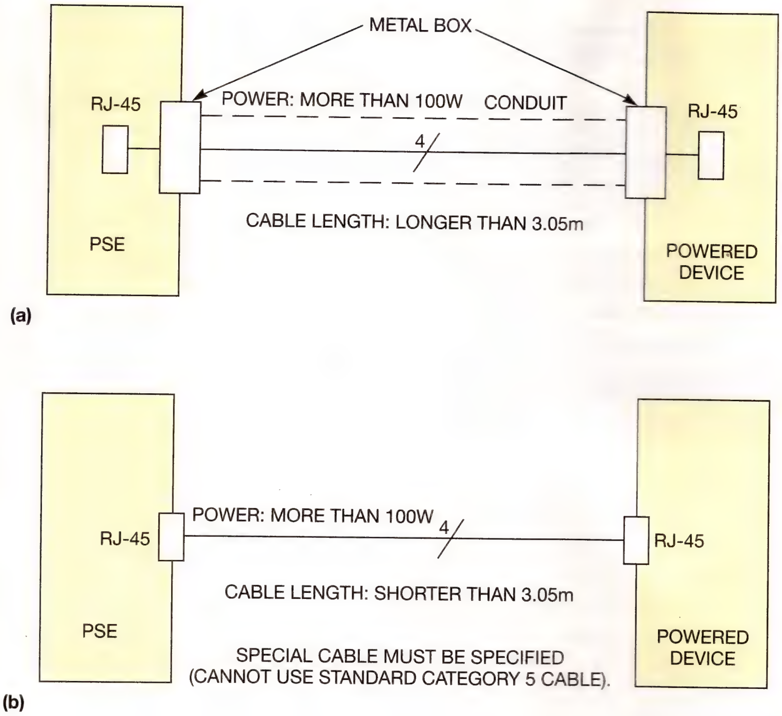
METAL BOX
RJ-45
POWER: MORE THAN 100W
CONDUIT
4
RJ-45
CABLE LENGTH: LONGER THAN 3.05m
PSE
POWERED DEVICE
(a)
POWER: MORE THAN 100W
4
RJ-45
RJ-45
CABLE LENGTH: SHORTER THAN 3.05m
PSE
SPECIAL CABLE MUST BE SPECIFIED
(CANNOT USE STANDARD CATEGORY 5 CABLE).
POWERED DEVICE
(b)

Figure 2 These circuit implementations power 250W over cable lengths greater than 3.05m (a) and less than 3.05m (b).

Ethernet cable (**Figure 3**). Nothing precludes the connection of the two power interfaces—one over the two pairs using lines 1, 2, 3, and 6 and the other using the two pairs that use lines 4, 5, 7, and 8. This arrangement makes it possible to increase power delivery and fully comply with the standard. In a typical HDBaseT implementation, a 50 to 57V-dc power supply installs and powers the PSE, and all powered devices receive power directly over the HDBaseT link across all four pairs of Category 5-or-better cables.

With HDBaseT, core POE technology uses a 1A current for every two cabling pairs and uses three-event classification to identify compliant PSEs. This approach enables HDBaseT technology to transfer as much as 100W of continuous dc power per port from one side of the HDBaseT link to the other. The HDBaseT powering standard takes a step beyond the IEEE802.3at-2009 standard by enabling the powered device to identify the cable's length and resistance and draw more power when necessary, as long as the overall power consumption does not exceed 100W, rather than always assuming a worst-case cabling infrastructure. HDBaseT's ability to deliver as much as 100W of power over 100m using one LAN cable without any additional power source aligns with trends in energy usage and demand, as well as government-led efficiency improvements. The power level is more than adequate for supporting today's typical 40-in. LED TV, which requires 70W of power.

This year, the latest Energy Star 5.3 specifications from the US Environmental Protection Agency will restrict all TVs to 108W of power consumption, regardless of screen size, whereas Energy Star 6.0 is targeting a cap of 85W for all screen sizes. **Table 3** shows proposed Version 6.0 power specifications, which should become effective this summer (**Reference 1**). Both LCD- and LED-TV monitors should soon be averaging

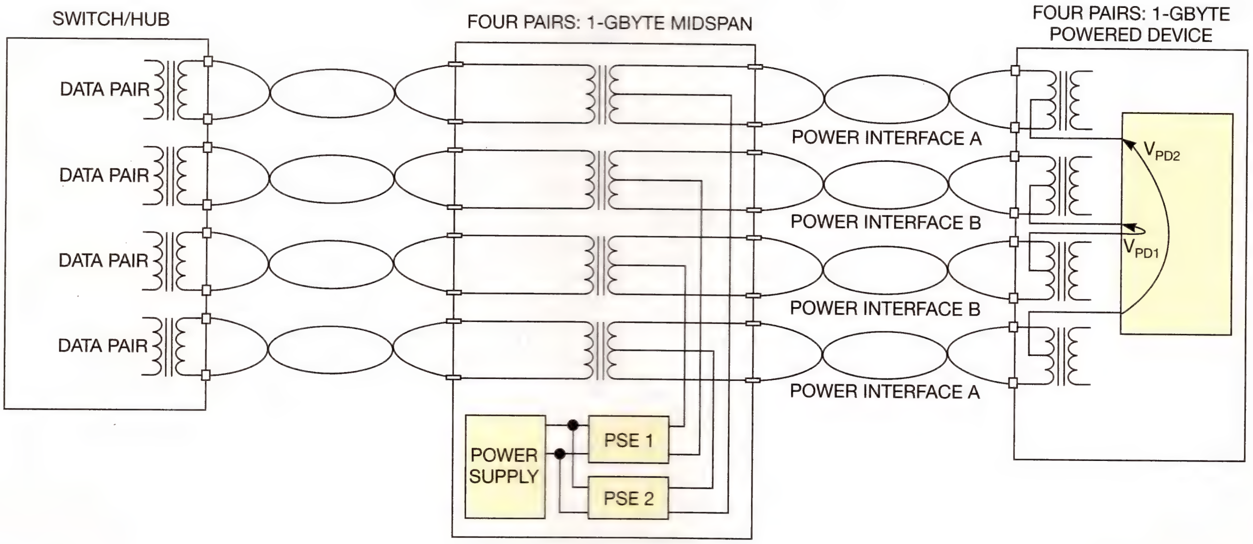

Figure 3 HDBaseT gives powered devices two power interfaces so that they can receive twice the power of two-pair approaches by using all four pairs of Ethernet cable.

TABLE 3 PROPOSED VERSION 6.0, EFFECTIVE SUMMER 2012

Viewable screen area, A (in.^{2})	P_{ONMAX} (W)
A<200	(0.055×A)+13
200≤A≤1068	(0.07×A)+10
A>1068	85

TABLE 4 RESULTING BASELINE DISTANCE EXTENSIONS

PSE source	Powered device power at 200m
Four pairs IEEE802.3at PSE (60W)	25W (802.3at powered device)
IEEE802.3at PSE (30W)	12.95W (802.3af powered device)
IEEE802.3af PSE (15.4W)	12.3W (802.3af Class 2 powered device)

approximately 1W of power consumption per inch of screen size. At these levels, the HDBaseT powering specifications can support even large displays.

Although today's Ethernet switches can and often do embed POE technology, another power-efficient way to deploy POE is through midspans, which reside between a non-POE switch and a network's powered devices. Midspans also are the most likely deployment model for HDBaseT because adding 100W per port in an Ethernet/HDBaseT switch would be a daunting engineering task and would greatly reduce overall system reliability. Midspans also feature remote power-device monitoring and configuration, which significantly reduces power consumption. Network administrators can monitor per-port and total power consumption and can configure power devices for instant and scheduled port on/off functions, as well as uninterruptible-power-supply-status-port on/off functions.

ETHERNET SWITCHES OFTEN EMBED POE TECHNOLOGY, BUT ANOTHER POWER-EFFICIENT WAY TO DEPLOY POE IS THROUGH MIDSPANS, WHICH RESIDE BETWEEN A NON-POE SWITCH AND A NETWORK'S POWERED DEVICES.

POE technology also can improve energy efficiency by minimizing the effects of idle power consumption. Many POE midspans and switches use switching power supplies, which are 90%-efficient at full load, meaning that they consume as much as 220W of ac power for 200W of POE power or as much as 440W for 400W of POE power. Unfortunately, switching power supplies when idle have switching-power losses of 20 to 40W with 0W load for 200W-rated units and 40 to 80W with 0W load for 400W-rated units. You can address this issue by exploiting POE's distributed-power architecture. For instance, network administrators can start with a 450W internal power supply to handle all real-time requirements and upgrade to full per-port power with an external 450W to 1-kW power supply when necessary.

One other key area of POE innovation is reach extension. Four-pair powering has enabled powered devices to work with cables as long as 100m, as the HDBaseT standard specifies. Today's POE midspans measure the cable length and correctly allocate power to a powered device when the cable length and the device's maximum power requirements are both known. This approach ensures that a powered device that connects across 100m and requires more than 22.8W will not unexpectedly disconnect when it reaches maximum load.

Network administrators can use extender technology to deliver both data and power to network devices, such as WLAN access points and network cameras, at baseline distances of 200m—that is, twice the distance of IEEE specifications. Extender devices simply connect to a midspan and receive power through the POE input. **Table 4** shows the resulting baseline distance extensions. You can also cascade extenders to reach even longer distances.

POE continues to evolve and offer a wider variety of high-value power-delivery and -management capabilities. As the technology moves beyond 60W to a new generation of higher-power capabilities, it is critical for designers to maintain compliance with all IEEE802.3at-2009 specifications, including those that ensure safe powering. The HDBaseT Alliance has adapted IEEE802.3at-2009 technology to a 100W technology that fully supports all safe-powering requirements and offers the opportunity to merge uncompressed full-HD digital video, audio, 100BaseT Ethernet, standards-compliant power delivery, and various control signals onto a single 100m Category 5e/6 cable.EDN

REFERENCE

1 Energy Star Television Specification, http://1.usa.gov/9nVSb.

ACKNOWLEDGMENT

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AUTHOR'S BIOGRAPHY

Daniel Feldman is the vice president of business development for the analog and mixed-signal group at Microsemi Corp and a member of the HDBaseT Alliance's POH (power-over-HDBaseT) technical committee. He is a former chairman of the Ethernet Alliance POE technical committee and was an active member of the IEEE802.3at task force. Previously, Feldman worked at Microsemi in several marketing roles, for PowerDsine as senior product manager responsible for outbound-marketing activities in the Americas, at IC4IC as system-architecture group manager, as a VHDL engineer at Nice Systems, and as VLSI engineer at Rafael. Feldman holds a master's degree in business administration from the University of California—Berkeley's Haas School of Business and a bachelor's degree in computer engineering from the Technion Institute of Technology (Haifa, Israel).

BY JEFF BARROW • INTEGRATED DEVICE TECHNOLOGY INC

Understand and reduce dc/dc-switching-converter ground noise

ONCE YOU UNDERSTAND THE TWO PRIMARY NOISE SOURCES, YOU CAN MINIMIZE THEM.

Dc/dc-switching power converters are notorious for physically disrupting otherwise carefully designed systems and circuit schematics. These converters drive unwanted charge onto electrical ground, causing false digital signals, flip-flop double clocking, electromagnetic interference, analog-voltage errors, and potentially harmful high voltages. As the complexity of these designs increases and applications become more densely populated, the physical-circuit implementation begins to play a critical role in the electrical integrity of the system. To address these issues, you need to learn how to reduce two major sources of ground noise.

GROUND NOISE: PROBLEM NUMBER 1

Figure 1 shows an ideal buck converter with a constant load current. Switches S_1 and S_2 toggle back and forth, chopping the input voltage across the buck inductance and the buck capacitance. Neither inductor current nor capacitor voltage can change instantaneously, and the load current is constant. All switching voltages and currents should successfully span buck inductance or pass through the buck capacitance, respectively, because an ideal buck converter produces no ground noise. But experienced designers know that a buck converter is a notorious noise source. This fact means that the circuit in **Figure 1** is missing some important physical elements.

Whenever charge moves, a magnetic field develops. Current in a wire, a resistor, a transistor, a superconductor, or a capacitor's plate-to-plate displacement creates a magnetic field. Magnetic flux is a magnetic field passing through a current-loop area and equals the product of the field cutting the loop surface at a right angle: $\varphi_B=B\times A$, where φ_B is the magnetic flux, B is the magnetic field, and A is the current-loop area. The magnetic field at a distance encircling a wire is directly proportional to the wire's electrical current, $B=\mu_o I/2\pi r$, where r is the magnetic field at a distance.

Electrical components have length, and charge must flow from one device to the next in the various wire segments. Moving charge creates a magnetic field, however,

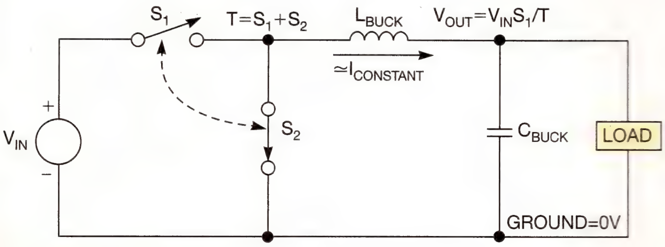

Figure 1 In a buck-converter circuit, inductor current cannot change instantaneously, so identifying a source of ground bounce in an ideal buck converter is difficult.

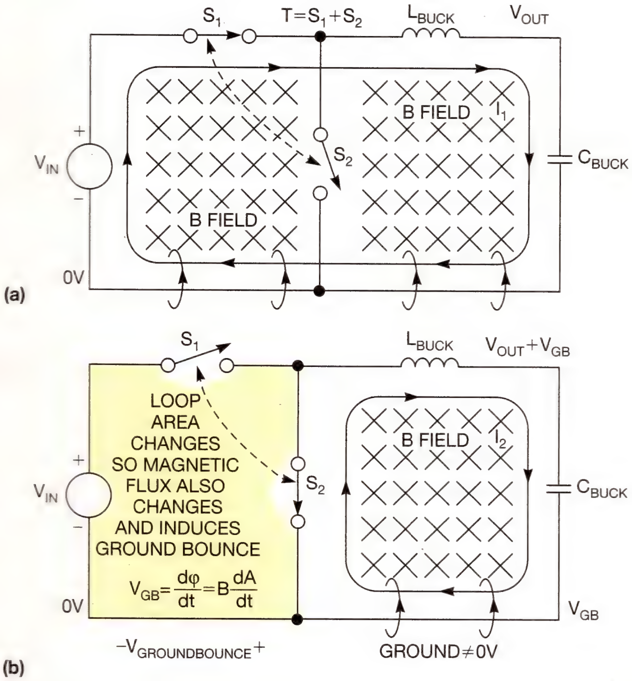

Figure 2 Changing flux induces voltage (a). As a buck switches, the changing current-loop path causes a changing flux and induces ground bounce (b).

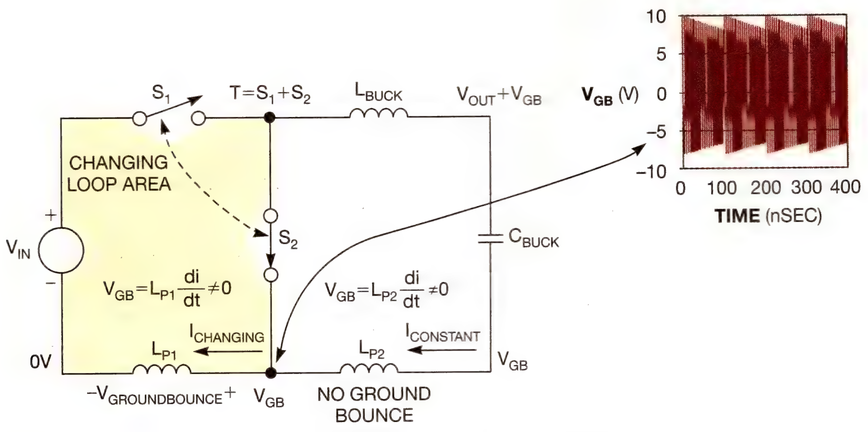

Figure 3 Changing current in L_{P1} induces ground bounce, whereas constant current in L_{P2} does not.

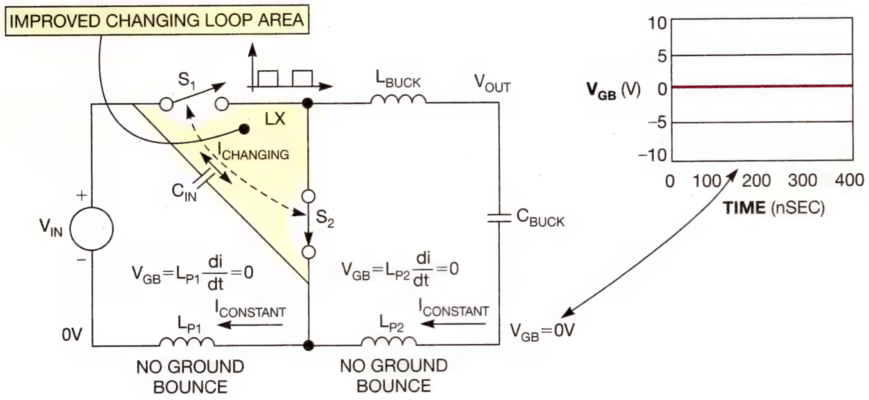

Figure 4 Careful input-capacitor placement minimizes the changing loop area and routes the changing current away from ground return to eliminate ground bounce.

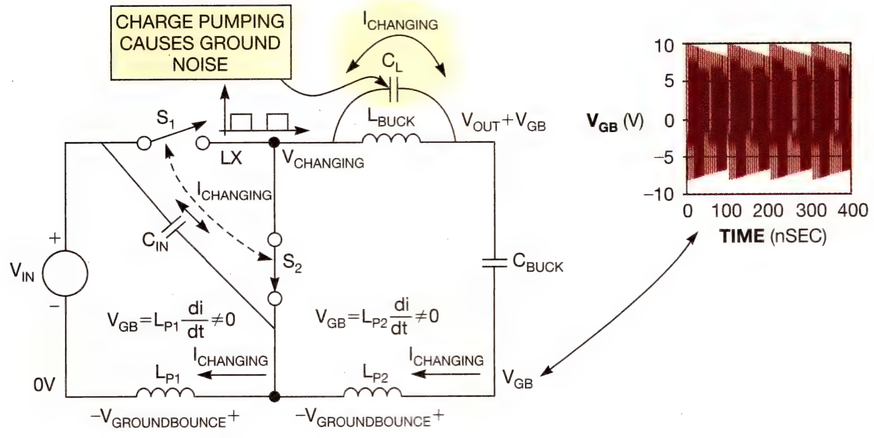

Figure 5 Changing LX-node voltage pumps charge through the parasitic buck-inductor capacitance, C_L, and into the parasitic ground-path inductors, L_{P1} and L_{P2}, causing ground noise.

so you can improve the circuit in **Figure 1**. **Figure 2** shows a better model of a simple buck converter. In **Figure 2**, the wire remains ideal in every way, except that current must flow some distance in each segment while traveling from one electrical component to the next. As this charge flows, magnetic field wraps around the energized wires and is magnetic flux passing through the S_1 and S_2 switch loops.

Changing S_1 and S_2 current-loop areas is the first major source of switching-converter ground noise. Magnetic flux in the input-voltage-to-S_1-to-ground loop grows and collapses on every switch cycle. That changing flux induces voltage everywhere in that loop, including the ideal ground-return line. No amount of copper, not even a superconductor, can eliminate this induced voltage. Only a reduction in the changing magnetic flux will help.

Changing magnetic flux has three factors: rate of change, magnetic-field strength, and loop area. Because the clock frequency and the maximum output current may be design requirements, minimizing loop area becomes the best approach. Inductance is proportional to magnetic flux.

Figure 3 shows an electrical model for **Figure 2** in which changing current in parasitic inductor L_{P1} causes ground noise, whereas constant current in parasitic L_{P2} does not. Although **Figure 3** presents the problem in a familiar way, it makes a poor substitute for the physically enhanced model in **Figure 2**. **Figure 3** shows parasitically induced voltage across L_{P1} and L_{P2}, whereas the arrangement induces voltage everywhere in a loop enclosing changing magnetic flux. This circuit element, however, still serves the purpose of showing how to reduce induced ground noise.

In **Figure 3**, ground-return current flows and changes in L_{P1}, and it causes a voltage-bounce problem. A carefully placed input capacitor reduces the parasitic magnetic-flux area and routes

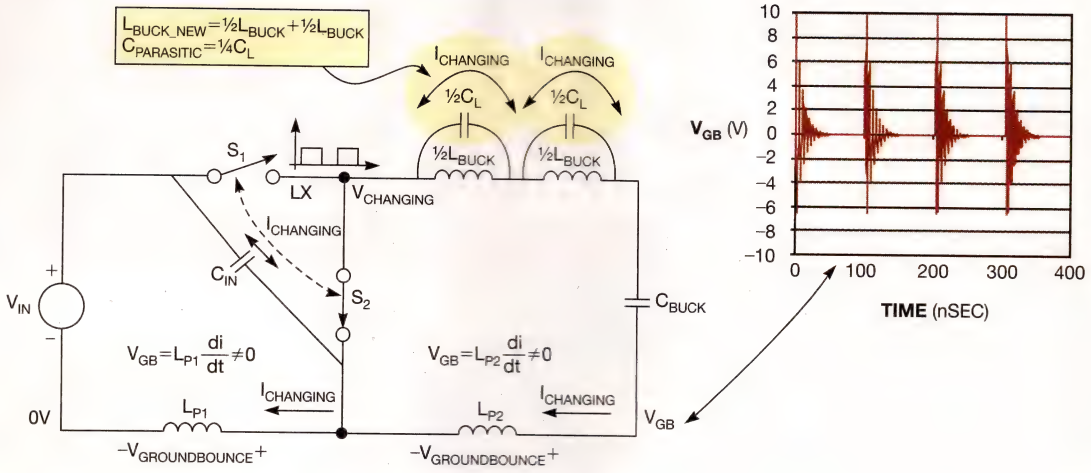

Figure 6 Two series-connected inductors have the same inductance but with one-quarter the parasitic capacitance; charge-pumping and, therefore, ground bounce decrease.

changing buck current in a path that does not include ground return (**Figure 4**). In this case, current in parasitic inductors L_{P1} and L_{P2} is constant, so the ground voltage is stable. The reduction in this magnetic-flux area also proportionally reduces EMI and all other unwanted, induced loop voltages.

The first important source of switching-converter ground noise is a result of changing magnetic-flux area. Good PCB design uses both trace routing and careful bypass-capacitor placement to minimize changing current-loop areas and changing current in a ground-return path.

GROUND NOISE: PROBLEM NUMBER 2

The second major ground-noise problem results from parasitic inductor capacitance (**Figure 5**). Voltage cannot instantaneously change across a capacitor, and current cannot instantaneously change through an inductor. So, voltage changes on the LX node couple directly across both the parasitic buck-inductor capacitance, C_L, and the buck-filter capacitor, C_{BUCK}, to appear across parasitic ground inductors L_{P1} and L_{P2}.

No charge initially flows, but, in the next moment, current builds in all of these components until the energy in the parasitic buck-inductor capacitor, $E_{CL}=½C_LV_{LX}^2$, transfers to the wiring's parasitic magnetic field, $E_{LP}=½L_PI^2_{CHANGINGMAX}$, where L_P is the sum of all parasitic loop inductors. That unwanted energy then passes back and forth from the electric to the magnetic field until it radiates or dissipates in resistive elements.

Both the peak voltage and the duration of a ground-noise oscillation are problems. The peak voltage, measured at node V_{GB}, is a function of the LX node's voltage change, the parasitic buck-inductor capacitance, and additional parasitic trace capacitance. A large parasitic buck-inductor capacitance stores more energy, so using a smaller one is a better approach. After selecting the buck inductor's inductance and current rating, choose an inductor with the highest self-resonating frequency to limit the capacity of C_L. An inductor's self-resonating frequency is expressed as $1/[2\pi\sqrt{(L_{BUCK}C_L)}]$. Doubling the self-resonating frequency reduces the parasitic inductor capacitance and, therefore, the ground-noise energy, by a factor of four.

When performance takes priority over cost, maintain the same value of inductance by replacing the single buck inductor in **Figure 5** with two series-connected inductors, each having half the value of the buck inductor (**Figure 6**). For a manufacturer's series of inductors, the parasitic capacitance is typically proportional to the rated inductance, so one-half the inductance results in one-half the parasitic capacitance. With series-connected inductors, their values add to increase inductance, but parasitic capacitors add as the inverse sum of inverse values to decrease total parasitic capacitance. In two series-connected one-half-buck-inductance inductors, total inductance will be $L_{BUCKNEW}$ and total parasitic capacitance will drop by a factor of four to one-quarter of buck-inductor capacitance. This reduction in parasitic inductance in turn reduces ground bounce.

By exploring the models and understanding the two sources and mechanisms of ground noise that the ubiquitous dc/dc-switching converter induces, engineers can minimize the effects in the early stages of design, component selection, and layout and can reduce the number of subsequent production headaches and re-spins.EDN

ACKNOWLEDGMENT

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AUTHOR'S BIOGRAPHY

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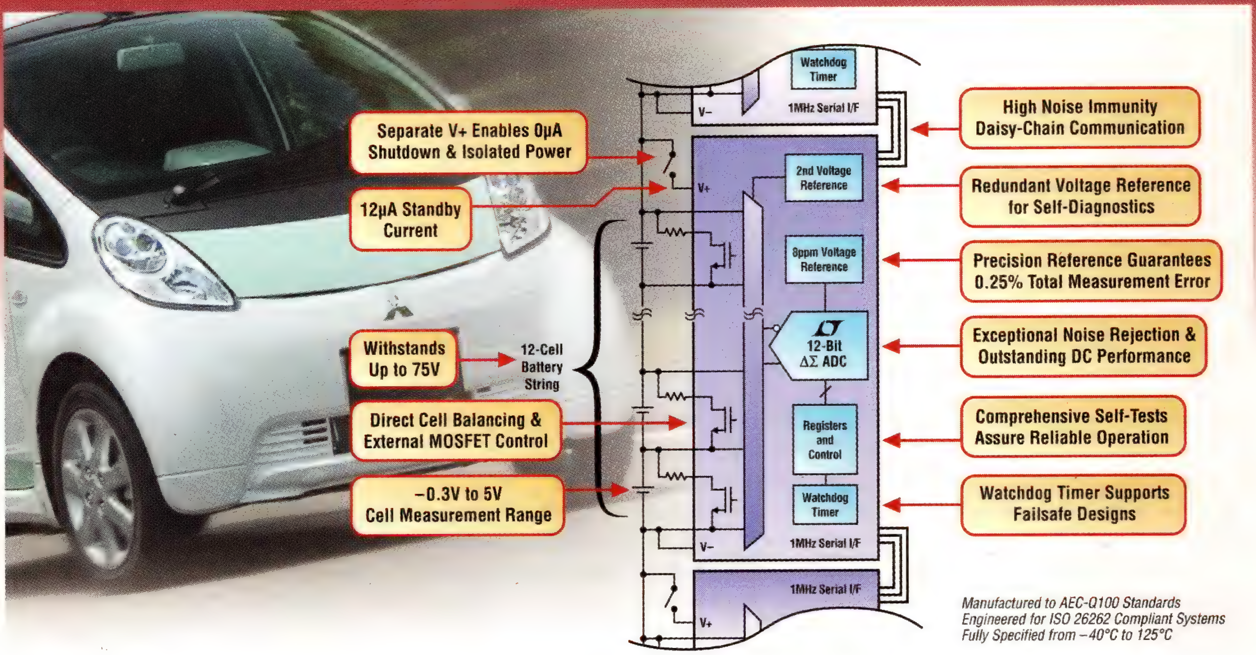
Road Proven Battery Stack Monitor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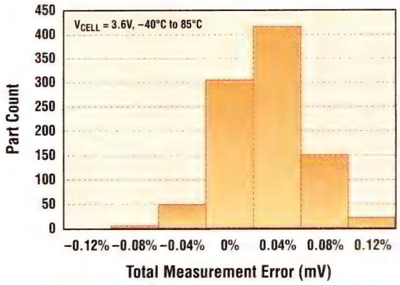

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READERS SOLVE DESIGN PROBLEMS

Simple circuit lets you characterize JFETs

John Fattaruso, Dallas, TX

When working with discrete JFETs, designers may need to accommodate a large variation in device parameters for a given transistor type. A square-law **equation** is usually used as an approximate model for the drain-current characteristic of the JFET: $I_D=\beta(V_{GS}-V_P)^2$, where I_D is the drain current, V_{GS} is the gate-to-source voltage, β is the transconductance parameter, and V_P is the gate pinch-off voltage. With this approximation, the following **equation** yields the zero-bias drain current at a gate-to-source voltage of 0V: $I_{DSS}=\beta V_P^2$, where I_{DSS} is the zero-bias drain current.

Figure 1 is a plot of this characteristic for N-channel JFETs showing the variation possible in a collection of devices. For example, the 2N4416A's data sheet lists a pinch-off voltage of –2.5 to –6V, and the zero-bias drain current can range from 5 to 15 mA. You can observe the correlation between these two parameters across a sample of devices. The outer curves in the plot represent these extreme cases, and the center curve represents perhaps a typical case of a pinch-off voltage of –4V and a zero-bias drain current of 8 mA.

Although you can design around a certain amount of device variation for a mass-produced circuit, you sometimes need a tool to quickly characterize an assortment of discrete devices. This tool allows you to select a device that will optimize one circuit or perhaps to find a pair of devices with parameters that match reasonably well.

Figure 2 shows a simple test circuit for this purpose. Although the **figure** shows the JFET as an N-channel device, the JFET DUT (device under test) may be of either polarity, as selected by switch S_1.

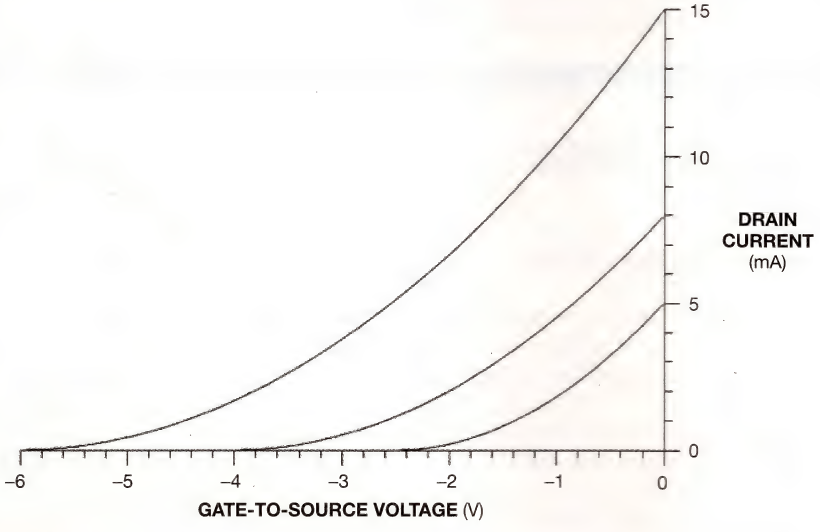

Figure 1 N-channel JFETs' I_D versus V_{GS} can vary widely among devices.

DIs Inside

50 Use a transistor and an ammeter to measure inductance

52 Use a three-phase rectifier and voltage reducer for offline single-phase power supplies

54 Lamps monitor beat frequency

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An external voltmeter connects to the terminals on the right. Switch S_2 selects two distinct measurement modes—one for the pinch-off voltage and another for the zero-bias drain current. In the pinch-off-voltage mode, the external voltmeter directly reads the pinch-off voltage; in the zero-bias-drain-current mode, the measured voltage is the zero-bias drain current across an apparent resistance of 100Ω.

With S_2 in the pinch-off-voltage mode, R_1 allows a few microamps of drain current to flow in the JFET under test, and the source voltage is a close approximation of the negative of the pinch-off voltage. The op amp acts as a unity-gain buffer, with negative feedback through R_3, so you can directly read the negative of the pinch-off voltage with the external voltmeter.

In the zero-bias-drain-current mode, however, the resistance from JFET source to ground is only 10Ω, so the drain current is a close approximation of the zero-bias drain current. The op amp's feedback also switches to a gain-of-10 configuration, with the inclusion of R_4 and R_5 in the feedback-voltage divider. This gain allows the voltmeter to easily read the small volt-

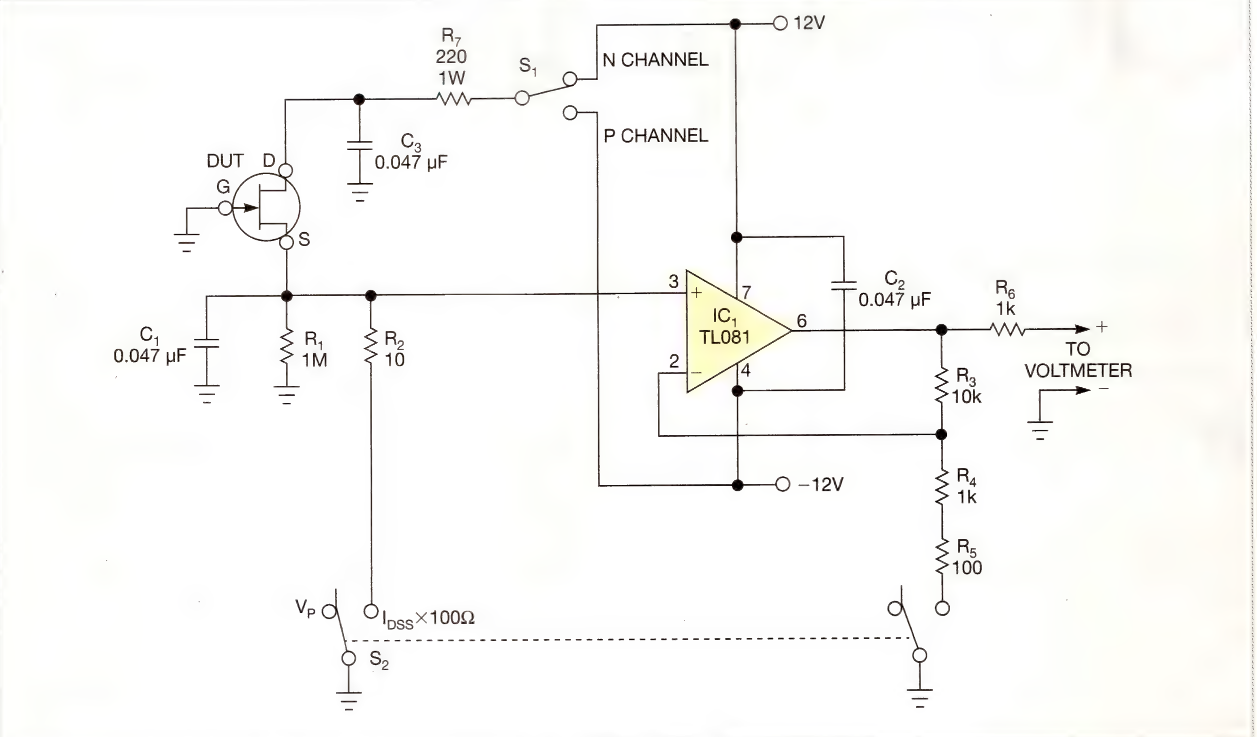

Figure 2 Selecting between the DUT's source resistors, R_1 and R_2, allows you to measure the pinch-off voltage and zero-bias drain current.

age across R_2, with the resulting reading being the zero-bias drain current times 100Ω. For example, if the voltmeter reads 1V, this voltage corresponds to a zero-bias drain current of 10 mA.

For an N-channel device, both voltage readings are positive; for a P-channel device, the circuit functions in the same manner except that the voltage readings are negative. If you wire the test JFET to this circuit with test leads and clips, each with some parasitic series inductance, you may need to add C_1 to suppress any tendency for high-frequency oscillation. R_6 isolates the op-amp feedback loop from any parasitic capacitance in the voltmeter and its leads, preserving the loop stability. R_7 protects against accidental shorts, and you can replace R_4 and R_5 with one 1.1-kΩ resistor. You are more likely to have on hand resistors with the values in the **figure**, however.

By clipping in samples from a collection of JFETs and throwing a switch, you can very quickly find the two parameters that determine where each JFET's characteristic falls in the range that **Figure 1** illustrates and select devices to optimize circuit performance. **EDN**

Use a transistor and an ammeter to measure inductance

Raju Baddi, Tata Institute of Fundamental Research, Pune, India

Bipolar junction transistors transfer a current from a lower-resistance emitter to a higher-resistance collector. You can use this property to measure inductance by connecting a series inductance/resistance circuit in the emitter and biasing on the transistor long enough for the current to reach a maximum value that is at least five LR time constants. When the transistor's off time is equal to its on time but is still biased by a silicon diode, the LR current decays exponentially toward 0A. Using the transistor's current-source property, you can measure this current without hindering the decay process in the LR circuit.

The transient analysis of an LR circuit shows that if, during the off time, the LR circuit's current reduces to a sufficiently low value, say 5% or less, then, for the on time plus the off time, the average current is directly proportional to the value of the inductance. You can control the currents through the transistor and an LR network using timed switching circuitry.

In an inductance-measuring circuit (**Figure 1**), the NE555 connects as an astable multivibrator oscillator to produce a square wave of approximately 50% duty cycle at frequencies of approximately 46 Hz, 230 Hz, 2.3 kHz, and 23 kHz, depending on the position of the range-selector switch. These values correspond to a full-scale inductance-measurement range as high as 2.5H, 500 mH, 50 mH, and 5 mH. This

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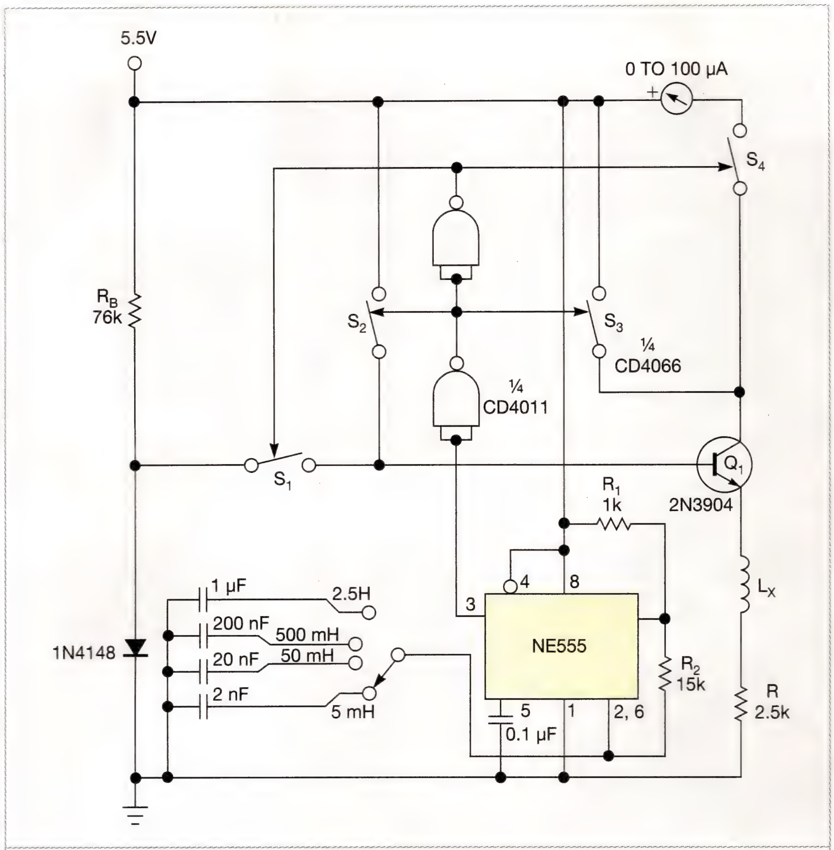

Figure 1 In this inductance-measuring circuit, the NE555 connects as an astable multivibrator oscillator to produce a square wave of approximately 50% duty cycle at frequencies of approximately 46 Hz, 230 Hz, 2.3 kHz, and 23 kHz, depending on the position of the range-selector switch.

square wave toggles four quad-packaged CD4066 switches alternately through a pair of CD4011 NAND inverters such that, during the on time, S_2 and S_3 are closed when S_1 and S_4 are off, and, during the off time, S_2 and S_3 are open when S_1 and S_4 are on.

At the start of the on time, S_2 and S_3 are closed, biasing Q_1 on from the 5.5V power rail, and the diode and meter disconnect through S_1 and S_4. After the current in the inductor under test, L_X, has exponentially reached maximum as the resistance determines, the off-time half of the cycle begins. S_2 and S_3 open to remove the 5.5V bias, and S_1 and S_4 close to insert the meter in the collector-current path and place a small diode-drop bias voltage on the Q_1 base.

Normally, the diode's bias voltage is a bit too low to keep Q_1 on. As L_X maintains the initial current, however, it drives the emitter negative to temporarily keep Q_1 on during the current decay. Most of the exponentially decaying LR current flows through the collector to the meter, and a small portion flows through the base and the bias resistor R_B, depending on the Q_1 current gain. The meter responds to the current average over the entire on- and off-time cycle due to the mechanical damping of the meter pointer. In this simple circuit, the meter deflection is directly proportional to inductance. With the values in the **figure**, the meter indicates approximately full-scale 100 µA when measuring a 5-mH inductor on the 5-mH range selection.

At the end of the off-time, the current through the inductance is almost 0A. An online appendix, at www.edn.com/120405dia, shows the current waveform and additional details, such as accounting for high inductor resistance and meter-scale factor. **EDN**

Use a three-phase rectifier and voltage reducer for offline single-phase power supplies

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M Pérez Suárez, University of Vigo, Spain; and A Abal Pena, Tekplus, Vigo, Spain

Some industrial applications require you to feed a low-power dc/dc converter from a three-phase source and possibly to deal with line-to-line voltages of 200 or 400V rms. Further, the neutral terminal of the ac source may be unavailable for connection, forcing you to use a line-to-line voltage link, which means a higher input voltage. Voltage faults can happen in one or two phases, and some applications require the power supply to keep working despite this problem. To handle these problems, you can use an uncontrolled rectifier and a capacitor to convert three-phase ac into a dc voltage, but this voltage may be higher than the maximum input voltage that a standard converter supports. It is difficult to find a dc/dc converter for these voltages, which are typically 564V dc or higher.

You can use the circuit in **Figure 1** to obtain a dc voltage lower than a given value, which the ratio of R_1 to R_3 sets. This value is approximately 340V peak with the values in the **figure**, from a 400V-rms or higher line-to-line three-

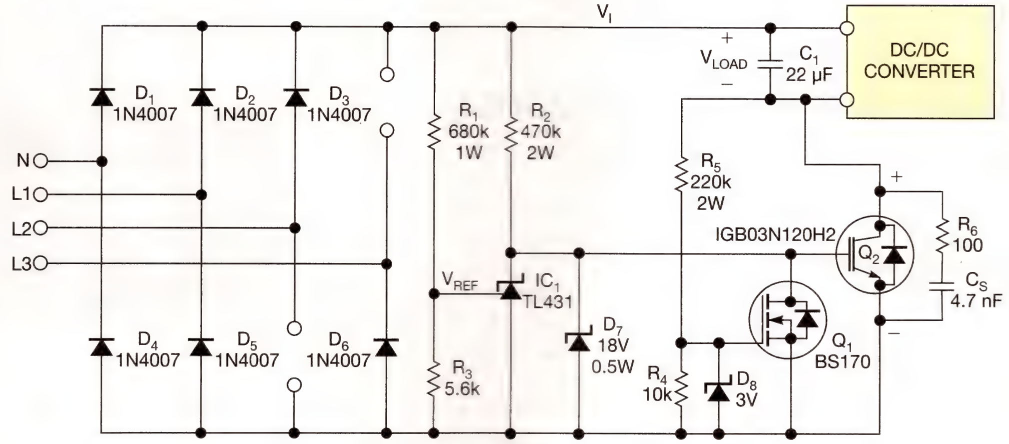


Figure 1 A three-phase rectifier uses a switched IGBT and a capacitor to reduce the voltage to standard offline dc/dc converters.

phase voltage. You can feed this value from two or three phases with or without the neutral wire or from just one phase with the neutral wire. This circuit omits two diodes from the typical three-phase rectifier bridge and includes a neutral-wire diode pair to obtain voltages below 340V across bulk capacitor C_1 and to reach 0V for initial start-up (**Figure 2**). If you connect the neutral wire, you must link it to a two-diode arm of the rectifier to achieve a 0V start-up; however, you can randomly connect the phase wires.

Shunt regulator IC_1 acts as a comparator. After the initial start-up, whenever the instantaneous rectified voltage, V_I, is higher than 340V, the IC_1 reference-to-anode voltage is higher than its internal reference of 2.495V, decreasing the anode-to-cathode voltage to approximately 2V and turning off Q_2. When rectified voltage is lower than 340V, IC_1 does not sink current. Thus, Q_2 turns on through the R_2 bias, connecting bulk capacitor C_1 and the dc/dc-converter load to the rectifier.

At turn-on, if C_1 is completely discharged and the instantaneous rectified ac-line voltage is greater than approximately 50V, MOSFET Q_1 is on, keeping insulated-gate bipolar transistor Q_2 off; no charging current flows into the capacitor. If the instantaneous rectified voltage is lower than the voltage across the bulk capacitor plus 50V, Q_1 is off and Q_2 turns on, connecting the capacitor and the load to the rectifier.

Notice that, especially at turn-on, the value of Q_2's $V_{CE}=V_I-V_{LOAD}$ rises to large values when Q_2 turns off, so R_5 must be as large as possible and must handle approximately 0.5W of power. Increasing the value of R_5 means that you must increase the value of R_4, more slowly turning off Q_1 and possibly resulting in a start-up malfunction. You must reach a practical compromise for the values of R_4, R_5, and D_8. Considering that D_8 limits the maximum gate voltage at Q_1, it must have a zener voltage as close as possible to the threshold voltage for a faster turn-off through R_4. A BS170 is a good choice for Q_1. You can add a snubber network comprising R_6 and C_S across the collector-emitter of Q_2 to limit the generated noise.

With the actual load voltage at 340V, IC_1's reference voltage is approximately 0.5V higher than its cathode, and the input transistor begins to conduct through the base-collector junction. You must measure this cathode voltage at 45 µA at 0.5V, and you must account for this value if calculating new values for R_1 and R_3. The simulation in **Figure 2** does not account for this input leakage and appears to switch at 310V. **EDN**

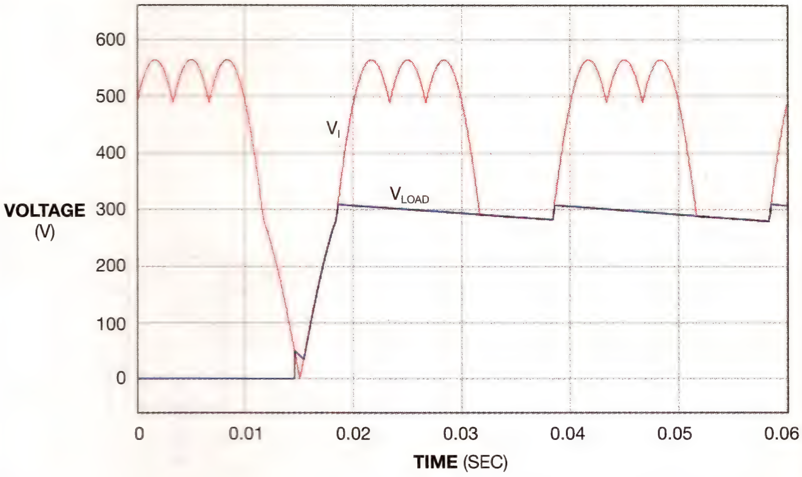


Figure 2 This circuit omits two diodes from the typical three-phase rectifier bridge and includes a neutral-wire diode pair to obtain voltages below 340V across bulk capacitor C_1 and to reach 0V for initial start-up.

Originally published in the March 5, 1979, issue of *EDN*

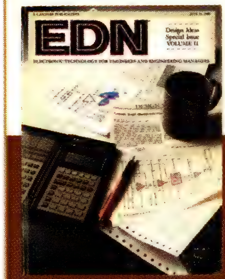
Lamps monitor beat frequency

Gerald L Assard, Naval Underwater Systems, New London, CT

You can synchronize an unknown frequency with a reference to obtain a zero beat by employing a visual monitor for the audio gap surrounding the near-zero frequencies. The visual beat-frequency monitor shown in **Figure 1** presents a method of obtaining a zero beat by monitoring two lamps. With L_1 on, the unknown frequency is too high; with L_1 off, the unknown is too low. At the point where L_1 changes state, L_2 flashes at a subaudio beat frequency. You can adjust the L_2 beat frequency to obtain the zero beat between the reference and the unknown.

The SN7413 Schmitt triggers (1 and 1A) furnish digital levels to the SN7474 JK flip flops (2 and 2A). These flip flops present a symmetrical square wave to the SN7400 beat-frequency detector (3) and lamp driver (4). Lamp L_2 flashes at the difference beat frequency developed by summing the phase of the reference with the phase of the unknown.

JK flip flops 5 and 5A present a ÷2 reset for the binary counters 6 and 6A and 7 and 7A. Either NAND 8 or NAND 8A can detect a two count. The higher frequency is always detected because it resets the lower frequency's binary counter before a count of two. The RS flip flops (9 and 10) store this detected higher frequency and drive the lamp driver (11). **EDN**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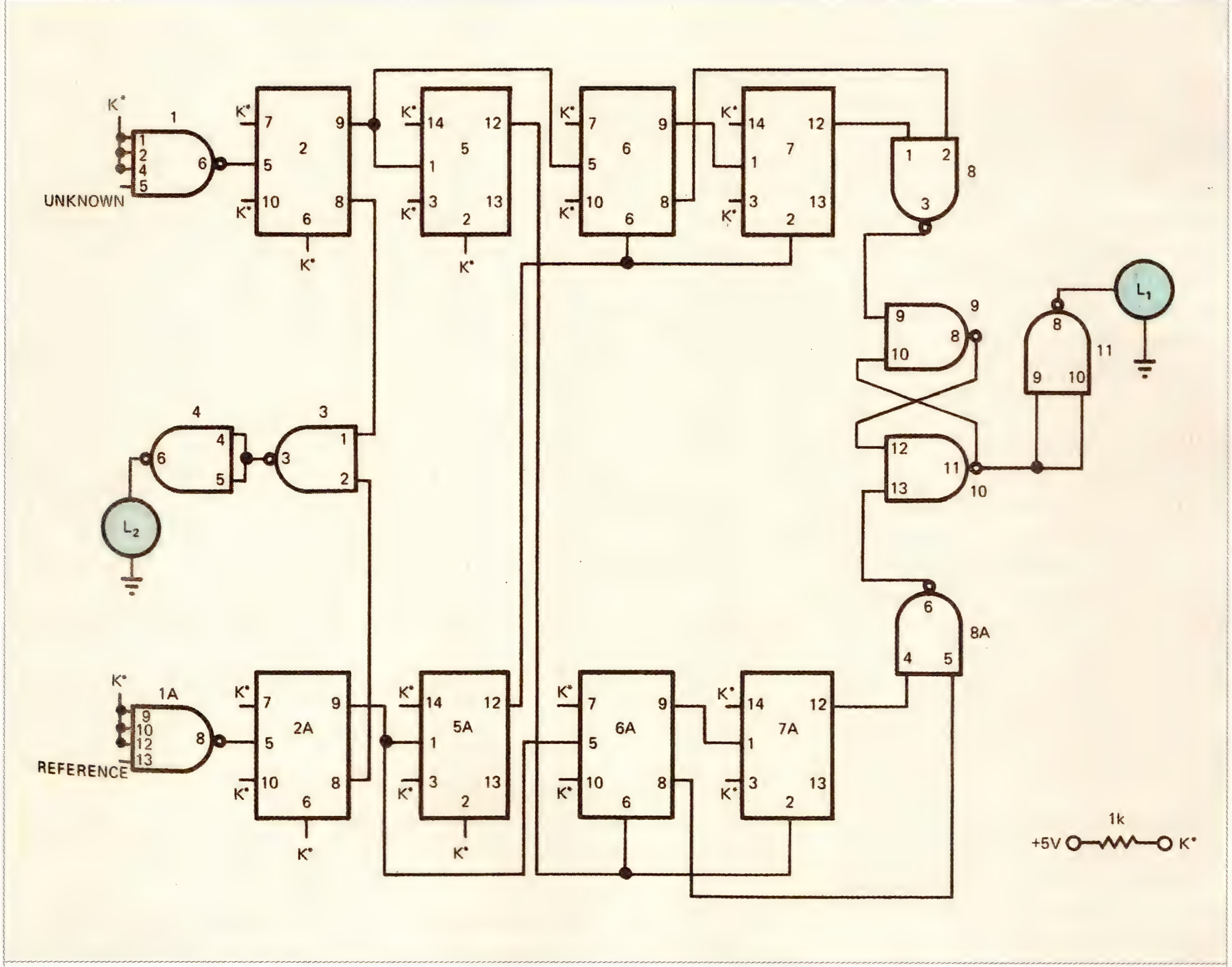

Figure 1 Two lamps furnish a visual monitor that allows you to synchronize an unknown frequency with a reference.

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DISCRETE SEMICONDUCTORS

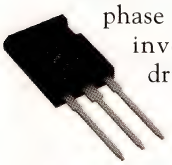
Infineon 40V OptiMOS has low on-resistance

The 40V OptiMOS T2 power MOSFETs have on-resistances as low as 1.7 mΩ at 10V and maximum drain currents as low as 25A. The automotive-qualified, lead-free MOSFETs come in TO-220, TO-262, and TO-263 packages. Because of package-geometry requirements, die-pad thickness, and chip size, the diffusion-soldering die-attach approach is suitable for only these package types. The devices offer 40 to 50% better thermal resistance than competing products, according to the vendor. The devices also feature no solder bleed-out, no chip tilt, and tighter on-resistance and thermal resistance than competing devices. They sell for 91 cents each (10,000).

Infineon Technologies, www.infineon.com

Cree's CMF10120D Z-FET SIC MOSFET touts energy efficiency

The 100V Z-FET family of silicon-carbide MOSFETs includes the CMF10120D device and replaces IGBTs in power-inverter designs operating at 3 to 10 kW. Applications include high-voltage power supplies and auxiliary power-electronics circuits, especially those that convert three-phase input power, solar-power inverters, industrial-motor drives, high-power-dc data-center power architectures, and PFC circuits. The MOSFET has a current of 12A at its operating temperature of 100°C. It delivers blocking voltages as high as 1200V with a typical on-resistance of 160 mΩ at 25°C. The device's on-resistance remains lower than 200 mΩ across its operating temperature range, reducing switching losses in some applications by as much as 50%, increasing overall system efficiencies by as much as 2%, and operating at two to three times the switching frequencies of IGBTs, according to the vendor. The device comes in a TO-247 package and is available from Digi-Key for $20.63 (one).



Cree Inc, www.cree.com

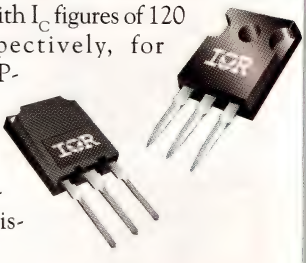
Diodes' DMP1245UFCL P-channel MOSFET delivers high efficiency

The DMP1245UFCL P-channel MOSFET has a maximum on-resistance of 29 mΩ at a gate-to-source voltage of −4.5V and a maximum drain current of −6.6A. Drain-to-source and gate-to-source voltages are −12 and ±8V, and continuous-drain current specs are −6.6 and −5.25A, respectively, at ambient temperatures of 25 and 70°C, respectively. Total power dissipation at an ambient temperature of 25°C is 613 mW when the device is mounted on the minimum recommended pad layout and 1.7W on a 25×25×1.6-mm FR4 PCB with high coverage of a single-sided, 2-oz copper. Gate protection is 3 kV, 50% higher than the nearest equivalents, and the off-board profile of 0.5 mm is 20% thinner than that of competitive equivalents, according to the vendor. The MOSFET sells for 15 cents (3000).

Diodes Inc, www.diodes.com

IR's IRGP4067DPbF, IRGP4066DPbF tackle 600V UPS, solar apps

The IRGP4067DPbF and IRGP4066DPbF IGBTs can switch at 8 to 30 kHz and have a 5-μsec short-circuit rating. Other key features include a maximum junction temperature of 175°C and low EMI. Breakdown voltage is 600V with I_C figures of 120 and 75A, respectively, for the IRGP4067DPbF and IRGP4066DPbF; voltage drop is 1.9V; junction-to-case thermal resis-



tance is 0.20 and 0.33C°/W for the IRGP4067DPbF and IRGP4066-DPbF, respectively. The IRGP4067-DPbF comes in a super TO-247 package and sells for $4.58 (10,000); the IRGP-4066DPbF comes in a standard TO-247 package and sells for $4.80.
International Rectifier, www.irf.com

SemiSouth's SJDP-120R340 SIC JFETs have low switching loss

The SJDP120R340 normally on SIC trench JFET features a continuous drain current of 8A, a pulsed drain current of 5A, power dissipation of 48W, and a gate-to-source voltage of −15 to +15V. Targeting use in solar-inverter, photovoltaic-microinverter, motor-drive, induction-heating, SMPS, PFC, and UPS applications, the device has a typical on-resistance of 340mΩ. The device's positive temperature coefficient eases paralleling and fast switching with no tail current at 150°C. The device sells for less than $7 (1000).
SemiSouth Laboratories, www.semisouth.com

Skyworks' SMP1325-087LF PIN diode targets switching applications

The surface-mount SMP1325-087LF PIN diode has a maximum resistance of 0.55Ω at 100 mA and a maximum capacitance of 0.6 pF at 20V. The device's 2W power rating enables it to handle 50W continuous-wave and 500W peak power with a 1-μsec pulse and a 1% duty cycle in a shunt-connected transmit/receive switch. Insertion loss is 0.04 dB and linearity is 90 dBm. The device comes in a 2×2-mm QFN package and is available from Digi-Key for 80.384 cents (3000) or 78.5 cents (6000).
Skyworks Solutions Inc, www.skyworksinc.com

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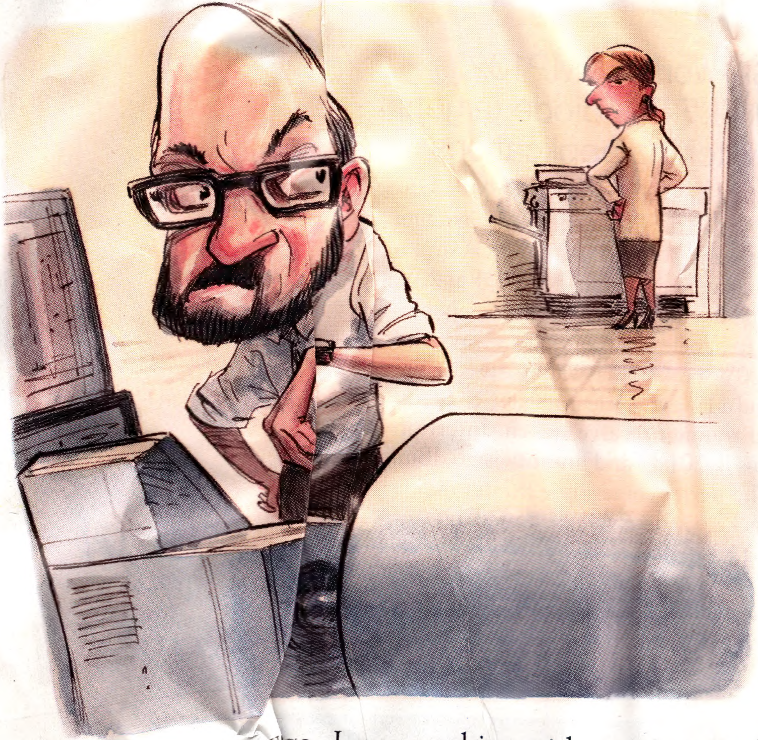

DANIEL VASCONCELLOS

A few ygo, I was working with servo controls
for w 20-foot-wide rolls of paper from pulp
to pa processing. Servo loops with various
feedb monitoring devices hydraulically con-
trolle lls. When you wind paper, the ten-
sion face has to decrease as the diameter
increases. Otherwi ou remove the roll from the spindle,
it could shoot acro and possibly kill someone. At the
time, operators no rmed tension control manually by
watching a pressure sing trial and error. A taper-tension
technique automat the tension on the take-up roll. A
contact-type "danc previously measured the diameter
of each roll, but, in anted to go "no-contact" with an
ultrasonic-transcei approach involved no micropro-
cessor; it used simp drivers controlling Moog valves.

The system used a only slightly modified one of the exam-
conductor LM1812 les. The prototype powered up with
ceiver and a 75-kHz tr problems—and no smoke. I set up
prototype on perforat arget fixture and started to fine-tune
copper-clad on one sid rything, and it worked—sort of. I had
ground plane for the R er been proficient with RF circuits, so
each through-hole c pleased with myself. Even with my
an oversized drill bit ektronix 465 oscilloscope, I could
copper and then hard e transmitting and echo pulses,

As usual, National went to my start-stop counter cir-
notes provided a nice displayed an arbitrary count with no timebase for distance. This count then went to a DAC for the analog control in the hydraulic-control loop.

All of a sudden, everything flatlined. I couldn't see any reason for it, so I started to adjust the coil slugs, which got it to work again. This flatlining scenario kept happening every so often, and it was driving me nuts. I began to time it and found that it would quit for about 30 seconds every 10 minutes. I figured that something in the area was jamming my frequency, and I tried all kinds of shielding by placing boxes around the LM1812 and certain other components. I even added a twin-T filter tuned to the specific frequency. Nevertheless, the problem recurred about every 10 minutes. I couldn't track it down with my scope; everything went fuzzy during the 30-second period.

I figured that it would act differently in the field in which it would operate, so I made plans to take it there. I updated and made copies of my designs. From the copier about 20 yards away, I could see my oscilloscope flatline. Meanwhile, I was leaning on the copier and felt a slight click and heard a faint whir. The damned copier was doing it! A heater and small fan inside the machine for heating and cooling turned on every now and then—30 seconds every 10 minutes!

The secretary yelled at me every time she needed to make copies because I always pulled the plug while I was "calibrating." She would then have to wait for the machine to warm up before she could continue copying. I put a line filter in line with my power supply and boxed it all up with good grounding, and everything was fine. I wonder how this copy machine passed Underwriters Laboratories, CE, and whatever other emission tests existed. It was apparently throwing wideband noise of significant power back into the 120V-ac line.

Nevertheless, in the war between our no-contact tension-control system and the copy machine, no lives were lost due to flying rolls of paper or irate office workers—both out to kill. **EDN**

Mike Page is a retired custom industrial-system control and instrumentation designer who now works as a free-lance power, ADC circuit designer.

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